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THE BUREAU OF STANDARDS

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THE scientific bureaus of the government in Washington are conducting investigations on a scale and of a degree of merit not fully appreciated by the public because so little is known about them. The Imperial Institution known as the Reichsanstalt in Charlottenburg, a suburb of Berlin, has acquired international fame; and the National Physical Laboratory at Teddington in the environs of London is nearly as famous as a government institution of research.

In no way inferior to these is our own Bureau of Standards, situated out on the hills in Washington toward Chevy Chase. It has just completed its tenth year. Its activities in the interest of standards of measurement and of excellence entitle it to as high a position in popular favor as it already enjoys in the esteem of scientific workers and of those applying scientific data to practical ends.

The two prime functions of the bureau are to serve the government and the larger clientele of manufacturers and ultimate consumers. To which beneficiary precedence should be given is a question; happily whatever serves the one serves also the other.

The bureau is by law the custodian of all physical standards, and is authorized by the act creating it to exercise such functions as are necessary for their construction, comparison, maintenance and dissemination. In addition to these duties is the highly important one of defining standards of excellence for manufactured articles and materials of construction of which the departments of the government are large consumers.

The division of electricity has made its full quota of contributions to the fixing of standards of electrical measurement in comparison with similar institutions of other governments. In recognition of this fact,

A View of present Buildings.

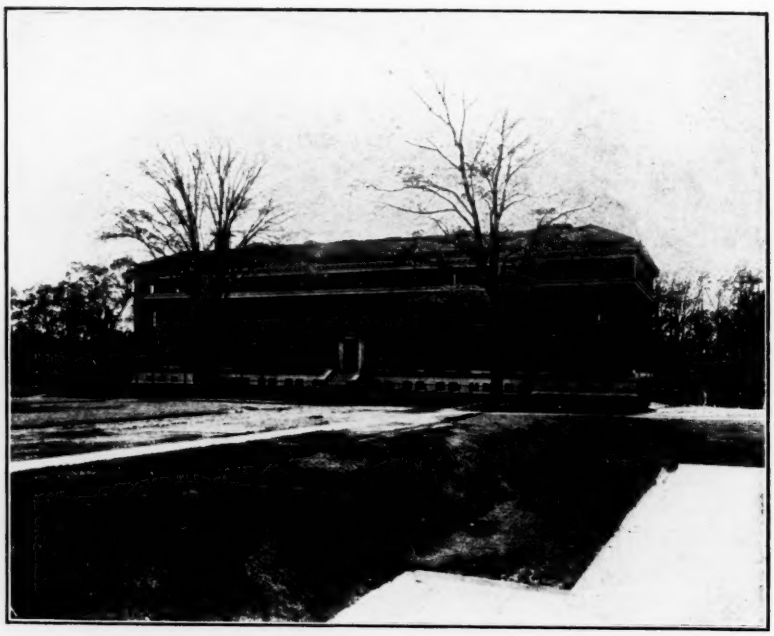
one delegate each from the Physikalisch-Technische Reichsanstalt of Germany, the National Physical Laboratory of England, and the Laboratoire Central d'Electricité of France came to Washington in April, 1910, and in cooperation with representatives of the Bureau of Standards carried out an extended series of experiments on the three fundamental standards of resistance, current and electromotive force. As one result of this cooperative work an agreement has been reached with respect to the value to be assigned to the Weston normal cell; it has been accepted by the International Committee on Electrical Units and Standards, and is therefore universal. The difficulties in the way of the complete unification of international electrical standards have now practically all been resolved.

In the other field of defining and maintaining standards of excellence, this division has been no less successful. The incandescent lamp industry is a shining example. Before the establishment of the bureau, the navy department was under the necessity of seeking the services of the German Reichsanstalt for the purpose of standardizing lamps for use in the naval service. At that time the different departments of the government purchased lamps on independent contracts, while purchasing agents had no scientific means of justifying awards. Hence the intrusion of political influence with the object of securing contracts for friends or constituents. Criticism of such action was not justified so long as the government was without the means of defining and defending standards of excellence to which the articles purchased should conform.

It has happened in the past that awards have been held up by congressional influence, and the awards have been modified to include the product of small manufacturers, who claimed to make lamps in every way the equal of those made by the large manufacturers of wider experience and technical skill. Subsequent tests at the bureau showed that some of these added awards were filled by lamps which did not meet the requirements of the contract, and they were rejected.

At the present time the general supply committee awards contracts for all departments of the government and the Secretary of the Treasury signs them. This year the contracts for the list of articles for which the committee has made awards aggregate about nine million dollars. All departments are furnished with lamps purchased under uniform specifications, and tested the year round by the bureau. Moreover, the government now has the advantage of million rates instead of the higher prices attaching to contracts for smaller numbers.

The lamp contract of the government calls for about one per cent. of the incandescent lamps made in this country. The other 99 per cent. are sold to the general public. If the government took the best million made, while lamps of lower efficiency and shorter life were sold to the public, the government would be the gainer at the expense of other



THE ENGINEERING BUILDING.

consumers. But the fact is that the check held by means of the life and efficiency tests made at the bureau, and by the work of inspectors who visit lamp factories with bureau standards and instruments, has had the effect of gradually raising the quality of all lamps made; so that the consumer at large has profited equally with the government in the improvement of the lamp product. The bureau cooperates with the technical staff of the best manufacturers, large and small, and is in this way influential in raising the standard of excellence. Since the lamp trust fixes and maintains prices, the only advantage the government gains by competition is the competition in excellence. A consignment of 50,000 lamps has just been rejected because they fell ten per cent. below the guaranteed life.

The work of other divisions of the bureau, while not appealing perhaps so directly to popular interest, are of no less value to the public weal. For example, the bureau is the legal custodian of the international primary standards of length and mass in the form of the national prototype meter and kilogram, by which the yard and the pound are respectively defined. From these and by methods and instruments of the highest precision our customary commercial and scientific standards are derived. In fact the integrity of our gold and silver coinage can be maintained only by occasional refined checks against the ultimate standard of mass in the vaults of the bureau. The prototype standards are composed of incorrodible metals in alloy; no standard

made of brass, for example, could be trusted to withstand the effect of oxidation during a long period of years, though happily a recent test at the bureau of the celebrated brass "troy pound of the mint" shows that it has not changed in the 83 years since it was received from England by more than 0.005 grain.

The Coast and Geodetic Survey is engaged in extending its measurements across the continent by means of triangulation. Formerly the survey had only about twelve base lines, each from five to ten miles in length, extending 3,000 miles from the Atlantic to the Pacific. These base lines had been measured with the greatest precision and at night to avoid temperature changes. The department is at present engaged in filling in intermediate base lines, which can now be measured readily by means of modern steel and "invar" tapes to one part in a million. Moreover, the work can be done daytimes and with steel tapes under known tension. The bureau compares these tapes, under the same tension and at the temperature of melting ice, with the primary standard of length, the national prototype meter. Thus it comes to pass that our continental surveys from Maine to California, and even to Alaska, are on the same basis of measurement as those made in other parts of the civilized world.

The bureau is charged with the duty of furnishing to the several states commercial standards of weights and measures in common use. It offers its services free to the state authorities and invites to a con-

A Corner in an Electrical Laboratory.

ference every year state and city sealers of weights and measures for the purpose of discussing the best methods of securing the use of legal measures of all sorts, and the prevention of frauds by the commercial use of fraudulent weights. The frauds committed against the government by the sugar refiners were nothing in comparison with those perpetrated on the people by short weight in small commercial transactions.

The bureau has in the field a force of inspectors, cooperating with the state authorities in the detection of fraudulent weights and of short liquid and dry measures. Some of these are used innocently, but many show unmistakable fraudulent intent. The fifth annual conference on weights and measures adopted a resolution favoring legislation requiring that all containers be plainly marked to indicate their net content; also that authority be given to the Bureau of Standards by congress to pass on types of weighing and measuring devices used in trade.

The division of heat has had a particularly arduous task to perform. In contrast to the certainty and permanency of standards of length and mass, and of electrical quantities, there have been great discrepancies in temperature scales and the thermal constants depending on them. The standards used by different makers of thermometers were not in agreement with one another, nor did they agree with the accepted gas scale. There were marked differences even between the usual limits of freezing and boiling, or 0° and 100° C. When the work on thermometry was undertaken, a large per cent. of American-made thermometers for temperatures as high as 400° to 500° C. were subject to changes of 30° or 40° when exposed to the high temperatures they were designed to measure. Further, the average clinical thermometers, used so extensively by physicians, were subject to errors exceeding the limit of tolerance. At least 30 to 40 per cent. of the clinical thermometers on the market at the beginning of the work would have failed to pass the requisite test; to-day only about five per cent. fail. The bureau now tests many thousands of them annually. So great has been the improvement in American-made thermometers that the German makers are complaining more and more of the loss of American trade in thermometers; and some familiar types of mercury-in-glass thermometers are no longer classed as instruments of precision.

Not only has the bureau authoritatively fixed the scale ranging from 0° to 500° C., but it has met a demand for the accurate measurement of very high temperatures by investigating optical and radiation pyrometers, in which the temperature of an incandescent body is measured by the amount of light or heat emitted. The intensity of red light emitted by a body at 1500° C. is over 130 times as great as at 1000° C.; and at 2000° C. it is more than 2100 times as great. Hence the possibility of a rough estimate of the temperature of hot bodies in the

arts by an experienced eye. The temperature scale of the bureau is now reproducible to about 1° at 1000° C. and to about 10° at 2000° C.

It should not be supposed that the constant efforts for higher accuracy are made to satisfy the dreams of the pure scientist; they are demanded by the requirements of technical tests and commercial processes. The character of some products is materially affected by a variation of 20° in the very high temperatures employed in their manufacture, and an accuracy of about 10° is required. To meet this demand there must be the exercise of many precautions and the elimination of many sources of error.

The importance of great accuracy is well illustrated by a test which the bureau was called on to make in a dispute between a purchaser and a seller of coal, in a case where the contract was based on the heat value of the coal, with a penalty clause for any deficiency in the heat value, and a premium for any excess above the stipulated one. A difference of about 0.05° was found between the thermometers used by the two parties. While this difference was small, it was sufficient to bring the parties into agreement, and to make a difference of some $25,000 a year in the money paid for the coal.

The division of optics has been engaged in many investigations of moment, but none of more practical value than the improvements in the application of polarized light to the testing of sugar solutions by means of the polariscope. Plane polarized light differs from common light in having all its vibrations reduced to a single plane. The optical property of a sugar solution utilized to determine the amount of sugar present is its property of rotating the plane of polarization when the polarized light passes through it. The degree of rotation determines the per cent. of sugar present.

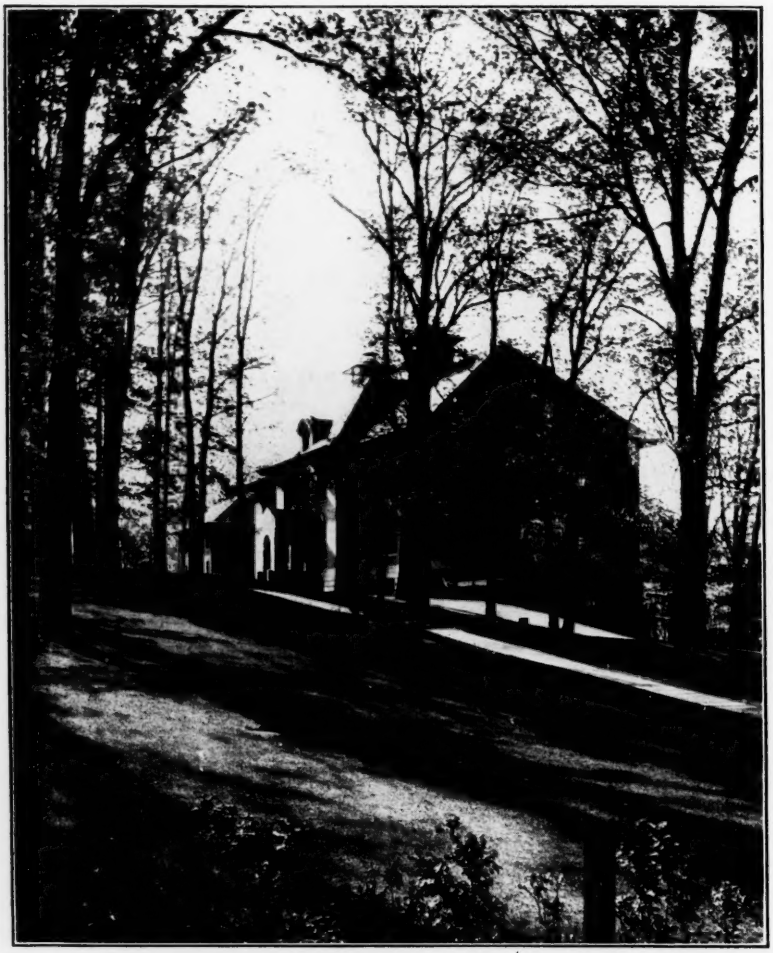
The bureau is able to make immediate application of its research work in this field, thus directing public attention to the results attained. As a result of the polariscopic tests of imported sugars at the bureau, the differences in the findings at the five principal sugar ports of entry have been reduced to 0.2 per cent. The importance of this work grows out of the fact that it increases the accuracy of the tests made on dutiable sugars and rigidly defines the scientific basis on which the revenues from them are collected.

The division of chemistry is in a large way auxiliary to all other divisions and cooperates with them in giving such service as chemistry alone can offer. It has been indispensable in the work of the division of electricity; it has prepared materials in the purest form for setting up Weston normal cells as standards of electromotive force, and for use in the silver voltameter for the international unit of electric current.

Much of the labor in testing supplies offered by the bidders under the new system of purchase by the General Supply Committee devolves on this division. The analyses of writing and printing inks, paper, and

mucilage alone amount to an annual total of about 2,000 samples. These chemical analyses and conjoint physical tests furnish a scientific basis for more definite specifications for future purchases.

A demand has developed for certified samples of iron and steel of definite composition; also for samples of sugar of the highest purity. Many hundreds of these are sent out annually. They are highly impor-



THE POWER HOUSE AND LOW TEMPERATURE BUILDING.

tant to encourage the growing tendency to apply pure science to commercial processes in place of haphazard traditional methods.

The engineering section of the bureau is one of the later ones established. It has already much more than justified itself. In addition to the work in Washington, designed to secure fundamental data for engineers, it carries on investigations at Pittsburgh in the building turned over by the Geological Survey by direction of the last congress. The

work in Pittsburgh under the old organization formed a part of the technological division of the survey.

The engineering division is performing an important service for the government in testing all cement made by the Atlas Cement Company for the Panama Canal. The company furnishes cement at the rate of 6,000 barrels a day. Inspectors are stationed at the works, and the bureau maintains there a well-equipped laboratory.

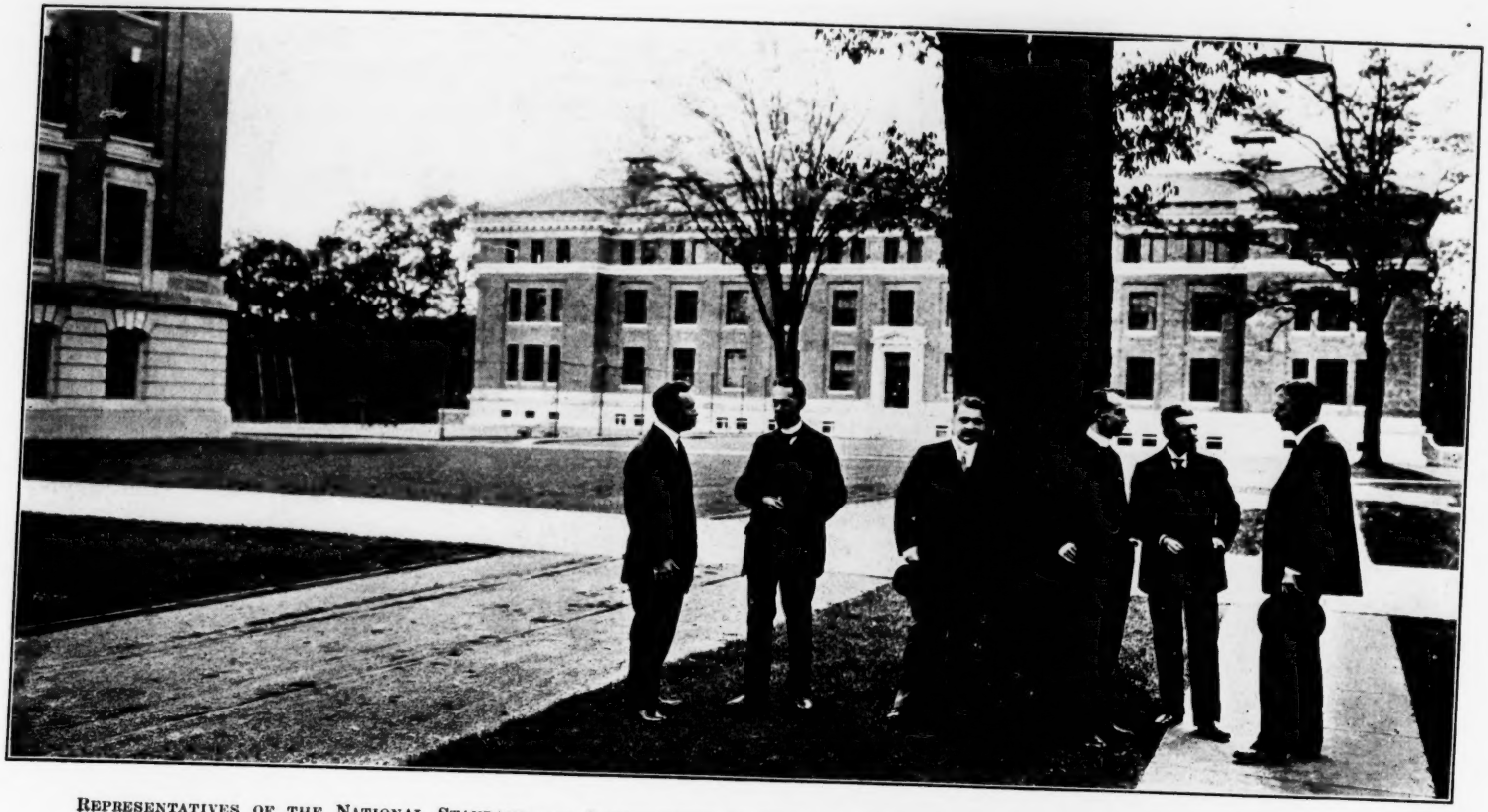
The testing of all paper purchased for the Government Printing Office falls within this division, in cooperation with the division of chemistry. Formerly bids were received on specifications, the lowest bid was accepted, and then the successful bidder proceeded to furnish the cheapest paper he could get accepted without further regard to the specifications. The results were that the best paper manufacturers refused to bid because they could not afford to sacrifice their reputation, and the government was defrauded. On one occasion the award for paper for the *Bulletin* of the bureau was made on specifications calling for paper of definite weight and half rags. When the paper had been made and submitted to the Printing Office, the analysis of the bureau showed that it contained no rags whatever, but only wood pulp.

At present print papers are bought on rigid specifications, and samples of all shipments are analyzed at the bureau. The fraud perpetrated on the government in the matter of print paper of all grades has now been eliminated.

Printing inks are purchased at present in the same manner, and the assistance of the bureau has saved the government in this particular item enough to cover about half the cost of the inks. The same system has stopped the graft by commissions once practised in the Bureau of Engraving and Printing by a trusted foreman. The price was very high on account of the generous commission allowed the foreman. Preferences for a particular make of ink or other commodity must now be supported by something more than the dictum of an old employee.

The engineering division does not confine its activities to the direct service of the government. Its aim is also to furnish scientific and physical data which lie at the foundation of engineering practise and design. It is now engaged in the actual measurement of the stresses producing compressions and elongations in the steel members of bridges and other structures after erection, as compared with those calculated by the designers. The results of such a comparison should be of eminent service to engineers and makers of structural steel, as well as to the government in the design and construction of its battleships. The largest testing machine, now in process of erection at the bureau at a cost of $150,000, is to be a marvel of precision. It will apply a maximum force of compression of 2,300,000 pounds, and will measure it with an accuracy of two pounds.

This brief survey of the activities of the Bureau of Standards is



REPRESENTATIVES OF THE NATIONAL STANDARDIZING LABORATORIES OF GERMANY, ENGLAND, FRANCE AND AMERICA AT THE BUREAU.

necessarily incomplete. It touches the high spots and refers only to matters likely to be of most popular interest. The work is progressing in all divisions with a vigor and comprehensiveness that promise even better results for the near future. The last congress made an appropriation of $200,000 for the erection of an additional building for the exclusive use of the division of electricity. The pay roll of the bureau includes about 280 names, and after July first it will be increased to something over 300. The additional assistants will enable several divisions to push forward work of great practical significance.

It would be an injustice not to say that the success of the bureau has been due in no small degree to the continuous service in their respective positions of Dr. S. W. Stratton as director, Dr. Edward B. Rosa as chief physicist, and Mr. L. A. Fisher and Mr. Charles W. Waidner as associate physicists at the head, respectively, of the divisions of weights and measures and of heat.

The scientific conclusions and data secured are published in a series of bulletins, which have now reached the seventh volume and which bear witness to the activity of this branch of the public service. In addition to the bulletins, circulars on important practical problems are issued from time to time; these are sent freely to persons and firms likely to need them in their professional practise or in manufacture. It is a matter worthy of the highest praise that party politics has never had any place whatever in the support or work of the Bureau of Standards.

ON THE HISTORY OF INTERNAL MEDICINE[1]

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AS a subject of general rather than of technical interest appropriate to this occasion, I propose to present a brief historical survey and some considerations relating to the development of internal medicine.

One of the primitive tendencies of human nature is the development and employment of procedures aiming at the relief of personal ailments and injuries. It is probable that all peoples have to a greater or less extent developed something in the way of therapeutic practises. In primitive stages of culture some agents of efficiency may have come into domestic and popular use; but the chief development of medicine in primitive societies has been in association with religious cults or superstitious observances. Originally medical practise was mainly a function of the priesthood. Even under such conditions the powerful force of psychotherapy must have been brought into action so as to be of benefit to distressed humanity.

Ancient writings have preserved to us some account of the therapeutic methods in vogue in the earliest historic civilizations, such as the Egyptian, Jewish, Babylonian, Assyrian, Indian, Chinese, etc.; among these medicine was chiefly practised by the priests. It was among the Greeks, however, and especially by Hippocrates and his associates 2,300 years ago, that the foundations were laid from which through a continuous line of existence and evolution can be traced the development of civilized medicine to its present state. Probably from the Egyptians and other antecedent and neighboring nations were derived some contributions to Greek medicine, but the derivation is not now clearly traceable, and practically the school of Hippocrates stands as the originator of the present era of medicine. Since his time the development of internal medicine has been intimately involved in four great epochs or movements of civilization and thought, so that its history is divisible into the following corresponding grand epochs:

1. Greek (also Roman and Byzantine) medicine; from before 500 B.C. to the fall of the Roman Empire,— A.D. 476 (Rome), 640 (Alexandria), 1453 (Byzantium).

2. Arabian medicine; about 750 to 1200 A. D.

[1] Presidential address before the George Washington University Medical Society, May 20, 1911.

3. Medieval medicine; about 500 to 1825. Monastic medicine; 500 to 1200. Scholastic medicine; 1200 to 1600. Systematic medicine; 1600–1825.

4. Modern medicine; since about 1825.

Greek Medicine.—The early medicine of the Greeks, as of other peoples, had mythologic and theologic characteristics. The god of medicine among them was Asclepios, or (Latinized) Æsculapius, who perhaps was a real physician flourishing prior to 1000 B.C. The temples devoted to his cult, called Asclepieia, were located in salubrious situations, or at mineral springs; invalids resorted to these institutions in large numbers, and were ministered to by the physician-priests. Famous Asclepieia were situated at Cnidos, Cos, Epidaurus, Pergamus, Tricca, Mycenæ and Sicyon. Gradually there developed in connection with these institutions associations or guilds of physicians called Asclepiadæ, who devoted their entire time to medical practise and instruction and had no priestly functions. The separation and differentiation of the functions of the physicians from the priesthood marked an important step in the evolution of medicine, as it left medicine and the medical profession free to develop along independent lines, entirely dissociated from priestcraft. These associations of Asclepiadæ formed schools for medical instruction and were centers of medical thought and influence. Such schools or guilds were located in Cnidos (Asia Minor), Cos (one of the Ægæan Islands), Rhodes, Cyrene (north Africa), and Crotona (Italy). The two most noted were those of Cnidos and Cos. Literary remains from the school of Cnidos have probably survived in the Hippocratic writings; while the school of Cos, which was flourishing prior to 500 B.C., produced the illustrious Hippocrates.

Hippocrates lived from about 460 to 377 B.C., a period when Greek culture and civilization were at their zenith. Originally trained in the temple and school of Cos, he traveled extensively and resided and practised in various places. His fame is derived from his writings. Of the works attributed to him, about sixty in number, only some ten to seventeen are regarded by the critics as being indisputably his production, the rest having been written by others before and afterward.

The Hippocratic writings constitute a systematic and comprehensive presentation of medical and surgical observations, doctrines and practise. Especial attention was given to prognosis, dietetics and meteorological conditions as causes of disease; and the beginning was presented of the humoral pathology, which for ages dominated medicine. All this mass of knowledge and doctrine could hardly have been discovered or elaborated by Hippocrates himself, but was probably mainly the accumulated knowledge of his predecessors first placed in literary form by him, and illuminated by his own keen observation, criticism and individuality.

There is little in the writings of Hippocrates of direct value to us to-day; yet while crude, imperfect, and visionary, they were of profound importance in the development of medicine. They constitute the first systematic literary presentation of pure medical science and art, aside from sacerdotal systems. They were, for the time, a very creditable beginning toward the development of rational medicine; and had progress in the subsequent ages been as substantial as that in the brief time prior to Hippocrates, the history of internal medicine for the ensuing two thousand years would not have been one of stagnation and inefficiency. Hippocrates showed himself to be a keen observer of clinical phenomena, a master clinician, and the part of his work of permanent value was the accumulation of clinical facts by observation, or the empirical method of developing medical knowledge which time has shown to be the only efficient method. Hippocrates displayed the noblest conception of the medical vocation, and in this, with his method of developing clinical knowledge, he set a standard and example for all time.

The doctrines of Hippocrates did not immediately gain general acceptance; soon after his death they nearly fell into oblivion, but six centuries later they were revived and given a vogue by Galen and then attained a dominant influence which they continued to exercise until the dawn of the modern era. During the interval between Hippocrates and Galen (B.C. 400 to 200 A.D.) a number of medical systems developed and continued in force for varying periods. The principal of these systems were:

1. The Dogmatic School.—This, based on the theories of Plato (B.C. 427–347), was developed by the immediate successors of Hippocrates, but it survived for only a few decades. The doctrines of this sect were highly speculative, and the humoral pathology was a fundamental tenet.

2. The school or following of Herophilus, originally located in Alexandria, flourished about B.C. 290 to A.D. 100. Herophilus, its founder, lived about 335–280 B.C., was one of the earliest anatomical investigators, and in part followed Hippocrates.

3. The school of Erasistratus, a famous contemporary and rival of Herophilus, also of Alexandria. His following flourished about B.C. 280 to A.D. 200.

4. The Empirical School, which existed about B.C. 280 to A.D. 117, was based on the skeptical philosophy of Pyrrho (B.C. 376–288). It rejected hypothetical speculations on the underlying causes and nature of phenomena, and recognized as valid only such knowledge as was derived from observation and experience. This school, therefore, had the only successful method of developing knowledge, identical with the modern inductive and scientific method, but it was not acceptable to the ancient and medieval habits of thought.

5. The Methodist School was founded by Asclepiades (B.C. 128–56) and his pupil Themison. It was an application of the atomic philosophy of Leucippus and Democritus to medicine, holding that vital and morbid phenomena depended on the movements of atoms or particles through pores in the body. The methodist doctrines exerted a strong influence on medical thought for many centuries.

6. The Pneumatic System, about A.D. 70 to 160, was founded and chiefly represented by Athenæus of Attalia. Its pathology was based on an aerial or gaseous principle.

7. The Eclectics, who date from about 50 A.D., had no common or distinctive views, but individually developed widely differing systems. Among them were included some of the most eminent physicians of antiquity. Aretæus (about 30–90 A.D.) was one of the earliest and most distinguished. Two other eminent writers of about that period deserve mention, namely, Celsus (about 30 B.C. to 50 A.D.), a brilliant encyclopedic writer on medicine, and Dioscorides (40–90 A.D.), who wrote a treatise on materia medica which remained an authority almost to modern times.

The greatest of the Eclectics was Claudius Galen (about 131–206 A.D.), of Pergamus and Rome. He received an exhaustive education at Pergamus (in Asia Minor), and other educational centers, and especially at Alexandria. He was a most prolific writer, not only on medicine but on other subjects, his works numbering between three and four hundred. He made important and extensive original contributions on anatomy and pharmacology. In internal medicine his system to a considerable extent was a revival and amplification of the doctrines of Hippocrates. So powerful was his influence that for nearly fifteen centuries Hippocrates and Galen continued the main authorities and basis of medicine.

From about the second century B.C. Greece and the entire civilized world of that time had come under Roman dominion; but though the political administration was Roman the culture and civilization of the Roman Empire was of Greek origin and character. The early medicine of the Romans was very crude, consisting mainly of superstitious observances under the auspices of soothsayers and priests; and there was no important Roman addition to medical knowledge. Later, Greek medicine and practitioners were introduced among the Romans, and prevailed until the fall of the Empire. Asclepiades (B.C. 128–56), the founder of the methodist school, was one of the main agents in establishing Greek medicine in Rome. Alexandria was for centuries the greatest center and headquarters of learning and education of the ancient world; it contained a vast library and produced important systems of philosophy and medicine.

Subsequent to Galen medicine in the Roman Empire came to a stand-

still or suffered decline, and the few writers who attained any note were little more than compilers of and commentators on the more ancient authorities. Greco-Roman medicine came to an end in the west with the fall of Rome in 476 A.D., while the capture of Alexandria and burning of its great library by the Arabians about 640 ended the intellectual influence of that city. In the Eastern or Byzantine Empire, Greek medicine continued for a longer time, overlapping the Arabian period. Among the important writers or compilers of this later (post-Galenic) period may be mentioned Oribasius (A.D. 326–403), Alexander of Tralles (525–605), and Paul of Ægina or Paulus Æginæta (about 600). Ultimately Greco-Byzantine medicine declined with the decay of the Eastern Empire, its last distinguished exponent being John Actuarius (died 1283); and the last remnant of the Roman Empire and of direct Greek influence came to an end with the capture of Constantinople by the Turks in 1453.

Arabian Medicine.—Soon after the Roman Empire fell, another people, the obscure Arabian tribes, energized by the religion founded by Mahomet, burst forth and established a vast dominion under whose fostering care enlightenment and learning were carried along during the centuries while Europe floundered in darkness and chaos. The Moslem era is dated from the Hegira, or flight of Mahomet from Mecca, in 622. Within a few years from this the Arabians, organized and inspired by the new religion, overran and conquered western Asia, northern Africa, and Spain, and over that wide territory established a dominion that lasted for six centuries. This dominion soon broke up into two independent divisions or sovereignties, the eastern Caliphate, embracing the Asiatic territories, and the western Caliphate, in Spain. About 750 two enlightened dynasties were founded, one in the east with its capital at Bagdad, the other in Spain with its capital at Cordova, both of which encouraged and developed culture and education to a high plane. The Moorish dominion in Spain was broken in 1212, and the eastern Caliphate was overthrown by the Mongols in 1258. The Arabian period of culture therefore covered the years from about 750 to 1200.

During this period the Arabian scholars collected and translated the learning of the Greeks, Persians and Indians, and cultivated the arts and sciences, especially architecture, philosophy, mathematics, astronomy, geography, alchemy and medicine. In some branches they made notable advances, as in mathematics; but in the main their chief service was more in conserving the learning of the past than in creating new knowledge. Important schools, libraries and hospitals were established, especially at Bagdad and Cordova, but also at Damascus, Samarcand, Bokhara, Seville, Toledo, Granada and numerous other cities.

In medicine the Arabians displayed great interest and proficiency,

and they produced a large number of writers and authorities on this subject. These were mainly translators, compilers and commentators of the Greek medical writings, so that their chief service to medicine was the preservation and transmission to succeeding ages of Greek medical lore; although they did make some material contributions in the differentiation of eruptive fevers and the introduction of certain drugs. The Arabians adhered quite closely to the authority of Galen. Of the large number of known Arabian medical writers three stand preeminent, Rhazes (850–932) and Avicenna (980–1037) of Bagdad, and Averroes (1126–1198) of Cordova.

Medieval Medicine.—During the four or five centuries following the fall of Rome (476), known in history as the Dark Ages, medicine in Europe shared in the general intellectual torpor of the period. No eminent medical writer or practitioner appears in the annals of christendom during this time. It is probable that the traditions and practise of Greek medicine gradually declined and the practitioners of the art became greatly degraded from their former standing. Ultimately medical and surgical practise came largely into the hands of members of religious orders (monastic medicine).

The revival of medical science in medieval Europe dates from the development of the famous secular medical school and university of Salerno in Italy, the first of the great European universities. Salerno was a salubrious town and health resort located on the seacoast a short distance southeast of Naples. The origin of the medical school at Salerno is obscure; it may have been founded by Charlemagne, and it is also supposed to have had early relations with the famous Benedictine monastery of Monte Cassino, north of Naples, which was itself a seat of a hospital and monastic medical school. The propinquity of Salerno to Sicily, which for a time was under Saracen dominion, made the Arabian influence accessible. The school of Salerno was in operation by the middle of the ninth century (846), Greek (Hippocratic) medicine being cultivated. The most famous and influential of its earlier teachers was Constantinus Africanus (1018–1087) of Carthage, who had traveled and studied extensively, and is credited with having introduced Arabian learning into Europe; he later became a monk at Monte Cassino. The school at Salerno was at the height of its fame and influence, which extended all over Europe, during the eleventh and twelfth centuries, but after the establishment of the great European universities in the thirteenth century it lost its preeminence and rapidly declined, though it continued in nominal existence until the nineteenth century.

The second European medical school was that of Montpellier, near the Mediterranean coast of France. The date of its establishment is unknown, but it was in operation in 1137; it attained the highest repute as a medical school, and has ever since continued in a flourishing and

influential existence. There was a celebrated hospital at Montpellier, taking advantage of the salubrious climate of the Riviera, and its proximity to Spain made the Moorish learning accessible.

The thirteenth century, in which occurred the downfall of Arabian empire and culture, saw in Europe a great intellectual revival. Many great universities were founded within a few decades from the year 1200, such as those of Bologna, Padua, Naples and Rome in Italy, Paris, Orleans and Toulouse in France, Oxford and Cambridge in England, and others. The medical instruction given in these institutions, and in others founded later, has ever since been the fountain of medical knowledge for the world and conferred upon the medical profession the stamp of learning and repute.

During the middle ages medicine shared in the intellectual characteristics of the period. It was an age of dogmatism and intellectual narrowness; the church exercised a censorship over all thought, and all tendency to mental independence and originality was repressed. The empirical method of gaining knowledge, that is, the accumulation of facts by direct and careful observation and study of natural phenomena, was rejected. This method was too slow and laborious, and left too many blanks in knowledge, to be acceptable. The ancient and medieval philosophers preferred to construct complete schemes of the universe out of their own minds, and took such pride in these brilliant creations of their own intellects, and regarded them as so complete and perfect, that observation of nature was regarded as superfluous and unnecessary. Men engaged in fine-spun controversies over metaphysical and theological subtleties and dwelt on the unimportant and unreal trivialities of their subjective philosophies, to the neglect of the important and real things of the objective world. Schools were plentiful and vigorous; but they were under the ecclesiastical control and influence, and simply fostered the scholastic dogmatism and dialectics. There were men in those days with as great intellects as the world has ever produced; but they frittered away their gigantic powers on inane trivialities. Dogmas and authorities were rigidly adhered to, originality and innovations were repressed, and for centuries mental advancement was inhibited.

Medieval medicine displayed all these characteristics (scholastic medicine). The doctrines of the ancients, especially Galen and Hippocrates, and of the Arabians were rigidly followed, and until the Renaissance there was no change and no progress. Medical thought was dominated by the humoral pathology or theory of disease, which had appeared as early as in the writings of Hippocrates. According to this theory health consisted in a perfect combination and action of the elements and humors of the body, while disease resulted from a derangement or corruption of them. Four humors were recognized, mucus, blood, bile (yellow bile) and black bile (atrabile). Mucus was sup-

posed to be secreted by the brain, and by flowing downward ("defluxions") into the respiratory and alimentary passages produced catarrhal and other diseases. Black bile was an entirely fanciful secretion of the adrenals. In crude or corrupted state the humors were supposed to be "acrid"—toxic or morbific; during the course of the disease they were believed to undergo a process of ripening or digestion—"coction" as it was called—to be finally expelled from the body at the crisis of the disease. The aim of treatment was to remove the acrid humors, or to promote their concoction and expulsion. Free bloodletting and other vigorous depleting measures were in general use.

About the sixteenth century began the great awakening of the world known as the Renaissance, which marks the end of the middle ages and the beginning of the modern era. This movement brought about a revolution in medical thought and yielded enormous acquisitions of medical knowledge.

The awakening in medicine was first manifested, in the sixteenth century, in the development of anatomical knowledge, as we have it to-day, under Vesalius (1514–1564), Jacobus Sylvius (1478–1555), Eustachius (1500–1574), Fallopius (1523–1562) and their successors, many of whose names are immortalized in our anatomical nomenclature more enduringly and more nobly than by monuments of bronze. The sixteenth century saw the labors of Ambroise Paré (1509–1590), the father of modern surgery, and important contributions in obstetrics and gynecology. In the seventeenth century modern microscopy was developed, and modern physiology may be said to have been founded by the epochal discoveries of William Harvey (1578–1657) relating to circulation and generation.

In the domain of internal medicine the Renaissance of the sixteenth century effected a revolution in, or release from, the rigid and dogmatic doctrines previously current. Nevertheless, the new doctrines were no nearer true or more effective than the old, and for three centuries longer internal medicine was destined to remain at a standstill before it too was really born into the family of modern sciences.

The first change was the overthrow of the authority of Galen (and the Arabians), which had previously been the main support of medical thought. This was brought about partly by the exact researches of Vesalius disclosing the errors in the anatomical teachings of Galen, partly by the effusions of the spectacular and mystical Paracelsus (1493–1541). The authority of Hippocrates continued to have weight for a much longer time.

Subsequent to Paracelsus and the break up of the ancient and Arabian medicine there developed a succession of speculative systems or schools of medical doctrine and practise, each of which had more or less general acceptance for a while, only to die out and be superseded by

its successors (systematic medicine). These systems were developed by distinguished teachers or writers, were usually mutually antagonistic, and left but little impress of abiding value or truth upon internal medicine. The chief of these medical systems were as follow:

In the seventeenth century:

1. The mystical system of Van Helmont (1578–1644), in which such factors as the fall of man, spirits, demons and witches figured as causes of disease; this system was a sort of recasting of the doctrines of Paracelsus.

2. The Iatrochemical system, originated by Franciscus Sylvius (1614–1672), attributed the phenomena of disease to chemical causes (as excess of acid or of alkali); but the chemical ideas underlying the system were crude and fantastic.

3. The Iatrophysical (Iatromechanical or Iatromathematical) system, originated by Sanctorius (1561–1635) or more especially by Borelli (1608–1679), explained physiologic and pathologic processes as brought about by the physical and mechanical activities of the body structures, and employed precise methods for measuring those activities. This system had considerable following, and while it may have contributed to physiologic knowledge it was ineffective as a basis for therapeutics.

4. The system of Thomas Sydenham (1624–1689), of England, who largely followed Hippocrates.

In the eighteenth century:

5. The eclectic doctrines of Herman Boerhaave (1668–1738), of Holland; he was preeminently a clinician, and in his day was the most celebrated practitioner of Europe.

6. Animism, the spiritualistic system of Georg Ernest Stahl (1660–1734).

7. The system of Friedrich Hoffmann (1660–1742), based on the mechanical and motor activities of the body.

8. The system of William Cullen (1712–1790), based especially on the nervous activities of the body.

9. The "Old Vienna School," founded by Gerhard van Swieten (1700–1772), and having Maximilian Stoll (1742–1787) as a distinguished adherent; this school largely followed a humoral pathology, akin to the doctrines of Hippocrates, Sydenham and Boerhaave.

10. The doctrine of "infarctus," introduced by Johann Kämpf (published 1780), according to which diseases in general were due to fecal impactions (or "infarcts") and therapeusis was based on rectal irrigation.

11. Vitalistic systems, based on the activities of the "vital force," supported by Bordeu (1722–1776), Barthez (1734–1806) of the school of Montpellier, Reil (1759–1813) of Germany, Bichat (1771–1802) of France, and others.

12. Brunonianism, founded by John Brown (1735–1788) of Scotland, based on the doctrine that vital and morbid processes depend on irritability or stimulations varying in intensity. It continued into the nineteenth century, especially in Germany and Italy, and has the evil reputation of having been the most vicious and harmful medical system ever practised.

In the first third of the nineteenth century:

13. The theory of excitement, a form of Brunonianism, in vogue in Germany.

14. The Italian system of stimulus and contrastimulus, an offshoot from Brunonianism, developed by Rasori (1762–1837).

15. Homeopathy, founded by Hahnemann (1755–1843), first promulgated in 1810, and still surviving as an example of ancient medical beliefs.

16. Broussaisism, so-called "physiological medicine," founded by Broussais (1772–1838) of France, and in vogue for a decade or two from about 1816, which looked upon gastro-enteric inflammation and irritation as the cause of diseases in general.

Thus the history of internal medicine shows a succession of ephemeral systems and theories from Hippocrates down to about the second quarter of the nineteenth century. In the various systems that developed a few factors stand out prominently around which the theories centered. Thus, the fundamental distinction between spirit and matter, or between living and non-living matter, furnished grounds for basing medical philosophies on the spiritual (or vitalistic) principle or on material factors, respectively. Among the materialistic medical systems, some (the "solidistic" theories) were grounded on the solid structures of the body, others ("humoral" systems) on the body fluids; some ascribed vital processes and derangements to chemical activities, others to the physical, mechanical or dynamic activities of the body structures ("mechanistic" theories).

Although centuries after the end of the middle ages in other respects, the second quarter of the nineteenth century may be fixed upon as the approximate termination of the medieval period of internal medicine, since down to that time the dominant tone of medical thought was about the same as it had been throughout the middle ages, or indeed since the time of Hippocrates. There had of course been some advance since Hippocrates, as in the differentiation of various diseases and the discovery and introduction of remedial agents; moreover, the development of scientific anatomy, physiology and chemistry could hardly fail to have had a salutary influence on medicine. Yet the dominant conceptions in pathology and etiology and the rationale of therapeutic practise were practically not more advanced, more rational, or more efficient a hundred years ago than they were two thousand

years ago. In the various systems that were propounded by the leaders in medicine, principles that were more or less true in a limited field were taken to be of universal applicability. Medical science and art can not, however, be reduced to one or a few general causes, laws and formulæ; each disease is a problem by itself, which must be worked out in all its aspects independently of other diseases. Hence the intellectual labors of a host of ingenious and talented thinkers for ages were wholly wasted, and effected no real advance in internal medicine, because they employed fallacious methods of thought.

Modern Medicine.—In the past seven or eight decades a radical transformation has taken place in internal medicine, pathology and therapeutics, which has put these subjects on the same high plane as any of the modern departments of science. There was no sharp dividing line of time between the old and the modern periods, but the new medicine developed gradually simultaneously with the decline of the old. The difference between the two depends on radical differences in logical method; modern medicine is developed by inductive, objective, empirical methods of attaining knowledge, the old doctrines were a product of theorizing and speculation. The evolution of modern scientific medicine has taken place along several independent lines of development.

The first branch of internal medicine to be elaborated on sound foundations was pathologic anatomy, its objective and obvious data making it facile of study. The pioneer in this branch was Morgagni (1682–1772) of Italy, whose epochal work on this subject appeared in 1761, when its author was 79 years of age. Other early workers in this field were John Hunter (1728–1793) of London and Bichat (1771–1802) of Paris. Bichat was followed by a brilliant group of French investigators during the first few decades of the nineteenth century, among the most eminent of which were Corvisart (1755–1821), Laënnec (1781–1826), Dupuytren (1777–1835), Andral (1797–1876), and Louis (1787–1872). The work of this group for a long time gave medicine a dominant pathologic-anatomical tone, especially in France.

The physical examination of patients by modern methods had its beginning in the introduction of percussion by Auenbrugger (1722–1809) of Austria. His method was published in 1761, but attracted no attention until it was revived by Corvisart (1755–1821) of France, who in 1808 published a translation of Auenbrugger's contribution which effectively brought it into use. The sister art of auscultation was introduced in 1819 by Corvisart's pupil Laënnec (1781–1826). Since that time there have been gradually developed the multitude of methods, physical, instrumental, chemical, microscopic and biologic, at present in daily use in the examination of the sick.

In the differentiation, clinical study and practical treatment of

the various diseases much advance was made after the first quarter of the last century. The British physicians made especially valuable and numerous contributions in this field, displaying a practical and clinical bent contrasting with the dominant anatomical tone of the contemporary French school. In the last decade of the eighteenth century Edward Jenner (1749–1823) had introduced vaccination against smallpox. The second quarter of the nineteenth century was one of active development and many important contributions were made by the British clinicians, typically and brilliantly begun by Richard Bright (1789–1858), of London, who in 1827 elucidated the subject of renal diseases ("Bright's disease"). Among others eminent in this period were William Stokes (1804–1878) and Robert James Graves (1797–1853), of Dublin; and John Hughes Bennett (1812–1875), of Edinburgh, who was influential in bringing about the disuse of bleeding. The conceptions of continued fevers, which had previously always been vague and confused, were immensely clarified about this time by the differentiation of typhus and typhoid fevers as distinct diseases; this result was largely brought about by a contribution in 1837 by an American, W. W. Gerhard (1809–1872), of Philadelphia. Anesthesia with nitrous oxide was introduced in 1844 by Horace Wells, a dentist of Hartford, Conn.; with ether in 1846 by another dentist, W. T. G. Morton of Boston; and with chloroform in 1847 by Sir James Young Simpson, of Edinburgh.

About the middle of the last century the medical doctrines of the French school were introduced into Vienna by Rokitansky (1804–1878), who with Joseph Skoda (1805–1881) and others were pioneers in that development of scientific medicine in Austria and Germany which has attained such eminence. The identification of the cells of plants and animals by Schleiden and Schwann about 1838 opened the way to new conceptions of vital processes, and in 1858 Rudolph Virchow (1821–1902) presented his epochal doctrine of cellular pathology.

The discovery of the pathogenic rôle of bacteria and the development of bacteriologic science has been one of the most illuminating developments in the whole history of medicine, elucidating, as it has, the pathology of the large and important group of infectious diseases and vastly increasing the efficiency of medical and surgical treatment. Following earlier scattered discoveries, the great foundations of bacteriology were established by Louis Pasteur (1822–1895), of France, beginning during the fifties of the last century. The introduction of improved methods of research by Robert Koch (1843–1910), of Germany, about 1882, gave the science a vast impetus. The principal application of bacteriologic science has yielded incalculable benefits to humanity, as in the introduction of antisepsis by Sir Joseph Lister (1827–) during the sixties of the nineteenth century, of the spe-

cific serum and vaccine treatment of certain diseases, of prophylactic measures, and of the specific methods of diagnosis.

The tremendous and revolutionary advance made by medicine in the past few decades is obvious to the most superficial view. It is quite apparent that internal medicine has just been having its Renaissance, even within the lifetime of men now living having passed through that stage of development that other departments of human thought and activity passed through centuries ago. We have only just emerged from the middle ages in medicine. The movement is still in unabated activity. The final goal is far from having yet been reached, and there are vast fields in medicine yet to be cultivated before the one-sided and partial developments of the past will be amplified into a more symmetrical and perfect form. With medical research and progress continuing at the present rate, the outlook is rich with promise for the future development of medicine and added benefits for mankind.

In looking over its history we can distinguish the operation of two contrary tendencies or methods of thought which have controlled the evolution of medicine. These two principles mark off the history of medicine into two epochs, the speculative and the scientific, of a distinctiveness more fundamental than the ordinary division into such periods as the ancient, Arabian and medieval. These two factors are: (1) the subjective, deductive, a priori or speculative, and (2) the objective, inductive, a posteriori, empirical or scientific, methods of attaining knowledge.

The subjective or speculative method is the one that prevailed throughout medical history down to the modern era. It is far the more attractive and has much the stronger hold on human nature; it is the primitive and natural method of the untrained mind. It is easy and pleasant to construct complete schemes of the universe by introspection. Scientific investigation is tedious and laborious, and leaves many gaps in knowledge. There is a demand in human nature for certainty, and completeness, and finality in knowledge. Our patients, for example, demand this in our diagnoses and prognoses. The mind is impatient with the unknown, and is prone to fill up the blanks in knowledge by premature generalizations and assumptions.

The objective or empirical method of gaining knowledge is the one that characterizes modern science. Rigidly suppressing preconceived notions and bias, this method proceeds by painstaking observation and investigation to collect an adequate mass of objective data as a prerequisite to generalization. This method is not natural to human nature, but is a product of culture. In the history of mankind, it was ages before, in the Renaissance, it came to dominate the best thought; and among the mass of people at the present time it is only a cultured few who are thoroughly imbued with its spirit.

The utter futility of the speculative method as a means of attaining effective knowledge is completely demonstrated by the stagnation and inefficiency of medicine under its influence for thousands of years. The only sure and effective way of gaining knowledge is the empirical method, by patient observation and investigation, the tardy adoption of which was the sole means by which internal medicine has been revolutionized and vivified. The keynote of the true method was struck by John Hunter in his advice to Jenner when the latter was beginning to ponder on the subject of vaccination, "Do not think; investigate." The whole history of medicine is an imposing demonstration of the futility of theorizing and the utility of scientific investigation. This lesson should come home to every one of us, and indicate the only mental attitude we can safely assume. We should formulate our judgments only by the objective and empirical route. We should avoid dogmatism, premature theorizing, and generalization from insufficient data. We should frankly admit our ignorance, and not deceive ourselves or others by unfounded assumptions. We should practise a healthy skepticism, and carefully scrutinize the information offered us. No authority is too eminent, no traditions too ancient, to be exempt from criticism. The vast amounts of chaff in our professional literature need to be carefully sifted for the few kernels of truth; while to a far greater extent the ready acceptance of the interested representations of commercial establishments is a mark of naive simplicity and easy credulity. Always as the test of verity should be demanded the evidence of and agreement with an ample body of objective data. These considerations may seem trite, yet experience constantly demonstrates the necessity for their vigilant observance.

It is disquieting to reflect on the inefficiency and even harmfulness of much of the medical practise of the past. Yet our predecessors were men of sincerity and high ideals, and had the trust and confidence of the mass of the people. The therapeutic successes of the past must be construed mainly as an exemplification of the potency and action of psychotherapy.

Although the scientific method imposes rigorous criteria for the acceptance of doctrines, yet truths so established rest on a firm and abiding basis. For this reason we can feel confidence in the validity and permanency of such of our present medical theory and practise as has a thorough scientific basis. We have good reason to feel that at last we have attained some degree of finality in many of our doctrines; that the medicine of to-day is radically different from the ephemeral systems of the past and wherever thoroughly grounded on a scientific foundation will stand for all time.

If it be true that medicine has only just emerged from the middle ages, some medieval error must still persist in our doctrines and

practise, which it behooves us to clear away. A keen criticism could doubtless disclose much of ancient error and fetishism in our materia medica and therapeutics and our pathological conceptions of obscure diseases. The entire profession does not even yet willingly and unreservedly accept the scientific element in internal medicine. The necessity and duty of thoroughly scientific methods in surgical and obstetrical practise is generally appreciated; but the obligation for equally thorough and scientific diagnosis and treatment in internal medicine is not so generally recognized. On the contrary, there is rather prevalent a spirit of disparagement and deprecation of what are called scientific methods, and insinuations are frequently made that they are not practical or useful. This spirit possibly arises not so much from frank conviction as from indisposition to keep fully abreast of the rapid developments in medicine, and a latent jealousy of those more advanced. That scientific methods in medicine (aside from those purely academic) are unpractical and useless is diametrically contrary to the reality; since it is such methods alone that have gained, and are gaining, and can gain for medicine all the real efficiency that it possesses. It is to me inconceivable that any methods in rational medicine can be other than truly scientific in their essence; sectarians, and laymen, and quacks can practise non-scientific medicine, but not true physicians. Our patients are entitled to the best possible service available, whatever be the character of any procedure that may be of use; and nothing short of this best is good enough for either the patient or the conscientious practitioner.

If a trained medical profession has only just found enlightenment, it can not be expected that the great untrained public will yet have emerged from medieval darkness in matters medical. The general public at the present time is actuated by the identical speculative spirit that for ages and until recently exercised its blighting control over the medical profession. A realization of this fact explains much that now seems anomalous and vexatious, and points the way of future betterment.

In many quarters the attitude of the public toward the medical profession is one of misunderstanding, distrust and antagonism. Fads and sects, like homeopathy, osteopathy and christian science, have a large and influential following, including the most intelligent and respectable members of the community. The hold which these (to us) irrational beliefs have on the public seems amazing and exasperating; yet the profession has only recently been emancipated from systems of precisely the same character—too recently for the public yet to have followed. Our customary attitude toward sectarianism is one of ridicule and denunciation; an attitude which produces infinitesimal results. These popular beliefs are not the product of perversity or wickedness, but result from powerful tendencies in human nature—the proneness

of the mind to speculative thought; and the proper remedy is not vituperation, but education. With the diffusion of medical knowledge among the people—not by hysterical propaganda but by gradual and substantial enlightenment—which seems inevitable now that the profession can exert its influence from an unimpeachable basis, greater mutual sympathy and understanding are bound to come between the public and the profession.

In its rational development internal medicine is the laggard among the medical sciences, having always been centuries behind such branches as surgery and anatomy. This is natural, since the data of the latter are superficial and obvious, while those of internal medicine are deep-seated, obscure and inaccessible, and allow much play for theory or imagination. Moreover, internal medicine lacks the spectacular appeal which is exerted, for example, by surgery. Yet though its data are inaccessible, its problems difficult, its therapeutic possibilities limited, the greater the difficulties the greater is the glory of surmounting them, and it is evident that internal medicine has at last entered upon a career in honor and efficiency second to none.

SCIENCE AND SOCIAL PROGRESS

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SCIENCE is usually defined as a classified body of knowledge; but this definition implies a completeness in our knowledge which the present discussion can not assume. In considering the effects of science on social progress, it will be necessary to go back of the advanced stage of scientific thought and take account of positive knowledge in its beginnings, before it assumed the classified form. Science as here used, therefore, refers to the spirit of investigating phenomena, or studying facts, as over against the spirit of mere speculation and of superstitious belief. The growth of science represents not merely a new spirit or state of mind in society, but it presents an explanation of the universe based on intelligence and reason instead of the emotions.

The consequences of the growth of positive knowledge are so complicated and far-reaching that it is impossible to follow them in all their ramifications. Only their more general effects can be indicated. The difference between knowledge and ignorance seems at first to be sufficient to account for the entire difference between progress and stagnation; but such is not the case, for certain kinds of progress, such as those which result from selection, take place independently of science. The effects of scientific knowledge are of two kinds, those which influence the mind and those which affect the environment. The first effect of science is to expand the mental horizon, giving us broader conceptions and a more active mental life. This is especially true of astronomy, which tends to bring us out of ourselves by giving us enlarged ideas of space and time and by revealing something of the process of the creation of worlds; but the same thing is true of other sciences which reveal the phenomena of matter in our own world and teach the wonderful laws of life.

A second result of science, which has been emphasized by Fiske,[1] is that it gives man a conception of law, an understanding of true cause and effect. This not only helps to develop man's mind, but it has an immediate effect upon his conduct, removing it from the influence of superstition to the domain of reason. When man learns to separate real cause and effect from the mere sequence of events, he can adapt himself to external influences and avoid much suffering. He learns

[1] "Outlines of Cosmic Philosophy," Part II., Ch. XXI.; reprinted in Carver's "Sociology and Social Progress," p. 478.

also to take account of the future instead of confining himself entirely to the present. For example, when man understands the true nature of such phenomena as volcanoes, earthquakes and floods, instead of attributing them to the vengeance of an angry god, he is in a position to protect himself intelligently from their injurious effects.

A third effect of science is that it restrains and directs the emotional life. In helping to make reason instead of passion the guide of our actions, it has done more than seems at first apparent, even though at times it has tended to go too far in stifling the legitimate action of the feelings. Under the increasing domination of reason man has had a better perspective and has been able to discriminate between important and unimportant things. At the same time he has attained greater self control. Instead of giving way to blind passion he has acted with greater and greater deliberation. This increased power of discrimination and greater self-control have had a remarkable effect upon man's actions. In giving him greater toleration they have done much to decrease strife. Man is much less likely to go to war over fancied grievances or over petty differences. And in all kinds of activities man is much more likely to count the cost before entering upon them. He will not, from a passing impulse, enter upon great undertakings which are impossible of execution. Reason, therefore, in supplementing impulse, has done much to cause man to avoid destructive and useless activities and to economize time and strength in the pursuit of useful ones.

The final result of science upon progress is the one most generally recognized. Science is the basis of art, and the progress of knowledge has stimulated and perfected the useful arts. Science has enabled us to make great strides in the conquest of nature, and has made possible to some extent the control of different forms of life. The resulting increase of wealth has made possible far greater happiness and has opened new channels of social progress. This result of science is so far-reaching that only the general effects can be mentioned here, the more detailed results will be considered later in connection with the separate sciences.

As the progress of science has altered the course of human progress so materially in the past, and as it is likely to be the most important factor in determining social progress in the future, it will be of great advantage to study the immediate causes of the advancement of science, as well as the social conditions in which these causes are most likely to be active. The distinction between the causes and conditions of the advancement of science is not hard to understand, though it may not be possible always to follow the dividing line exactly in discussion. Science is advanced by individual effort, and stimuli to the individual form the immediate cause of its advancement. But these individual

stimuli will act, or will act strongly, only under favorable social and physical conditions, and these last are what I have called the conditions of the advancement of science. They are a step farther removed from the product than the cause. As crops are cultivated in soils of different degrees of fertility, so science is pursued under conditions which are more or less favorable to its advancement; but science is not followed to any considerable extent, nor are the best results obtained, except under favorable social conditions.

The causes leading to the advancement of science are somewhat difficult to trace, so many and varied are the influences affecting the intellectual life. Doubtless our knowledge of science has been increased to some extent by chance discovery, but the amount of credit which should be given to this influence will depend upon our ideas of what is really accidental in discovery. The alchemists, in trying to produce gold from the baser metals, discovered a number of valuable chemical compounds. These discoveries were accidental in the sense that they were not the real objects of the researches, yet the compounds would not have been discovered if the alchemists had not been experimenting in the field of chemistry and with those particular chemical elements. Chance discoveries are seldom made far from the field which is attracting attention. Certain discoveries, like the properties of saltpeter, may have been wholly accidental; but such discoveries are rare. Therefore instead of making pure accident an important cause of the advancement of knowledge, it is more nearly correct to say that an unexpected element often enters into scientific discovery.

Another minor influence leading to the progress of knowledge is idle curiosity. Probably the early observations of the stars and the planets were due to little else. Few discoveries, however, can be attributed to this stimulus alone, although curiosity in some form doubtless enters into the majority of scientific discoveries. Professor Ward[2] quotes De Candolle as saying, "the principle of all discoveries is curiosity." But such an assertion gives us little help. Our task lies in attempting to discover the various influences which arouse curiosity. Mere curiosity, accompanied by no other motive, seems really to have had little influence in advancing science. It is true that students engaged in research may select one problem rather than another, simply because they have a greater interest in it; but their motive for investigating some problem is quite different from idle curiosity.

The greatest stimulus to the progress of science in its earliest stages is to be found in an attempt to achieve some great object. Although logically science is the basis of art, historically early art precedes science and is the greatest incentive to its advancement. The history of almost all the sciences shows that their beginnings lay in a desire to

[2] "Pure Sociology," p. 445.

attain some practical end, and in later stages also the same object still holds an important place. The desire to observe religious festivals regularly has stimulated the study of astronomy in order to obtain exact measurements of time. Among the Hindoos mathematics was stimulated by the requirements of religious worship in making their altars and laying out their courts. And according to Max Mueller[3] they also struggled with the problem of making a square altar of the same size as a round one. In Egypt, geometry got its stimulus from the need of parcelling out the land fertilized by the Nile. The progress of architecture also increased man's knowledge of mathematics and physics. The great European cathedrals were built before scientific works upon architecture appeared. It is said that the needs of Alexander's campaigns in Persia stimulated the study of mathematics and physics. And the desire to save human life has always been a great stimulus to the study of biology. These are simply a few illustrations of the kind of stimuli which have been most potent in the advancement of science.

After science has attained a start, if social conditions are favorable, it will progress without the immediate incentive of a practical need. As knowledge advances men begin to recognize its general value and try to extend it in every direction, believing in its ultimate, if not in its immediate, usefulness to mankind. This is science for the sake of science and is represented by the present period of scientific development. Such a method of increasing knowledge is never purely arbitrary, however. Not all truth is considered of the same value at a given epoch. If scientists have not always in view some practical end, they are more likely to be interested in those departments of knowledge which have a bearing on the immediate need of society. It will be observed, therefore, that this last influence, science for the sake of science, is not wholly separated from the preceding one, science for the sake of art, although a new motive is present. In addition to the need of solving an immediate problem, the value of all positive knowledge is recognized and becomes a new incentive in stimulating a study of the sciences.

With this brief enumeration of the chief causes of the progress of science, we may turn to the consideration of the conditions under which the pursuit of science is most likely to flourish. It seems probable that science is somewhat more likely to advance, at least after a start has been made, in cold or in temperate climates, than in warm climates. According to Professor Cattell's "Study of Eminent Men"[4] France has produced the largest number of scientists of any country, and England the next largest. This order is true not only in the absolute number, but

[3] "Origin of Religion," p. 142.

[4] THE POPULAR SCIENCE MONTHLY, Vol. LXII., No. 4, February, 1903.

also in the percentages of the total number of eminent men. Italy surpasses all countries in the proportionate number of artists. If the ancient civilizations were included in this comparison, the supremacy of the north would not be so evident; but it is hardly fair to include the ancient civilizations, for when they were flourishing, societies in northern countries had not advanced. When northern societies did develop they produced their quota of scientists, though they did not produce their proportionate number of artists.

The chief explanation of any advantage which cold countries may have in the development of science is to be found in their greater needs. The environment is harder to subdue and at the same time man's requirements are greater, hence there is a continual incentive to improve the useful arts: and the attempt to improve the arts is, as has already been said, the most important stimulus to the advancement of science. In addition to this, life in northern countries seems somewhat better adapted to the development of a thoughtful people. In southern countries social life is more continuous and the conditions are therefore less favorable for meditation. In northern countries social life is interspersed to a greater extent with periods of isolation, and this condition is most favorable to the development of new ideas. A more completely isolated life, however, with little social intercourse would not be stimulating enough to develop new ideas. Of course the most desirable balance between the social and the solitary life may exist in particular cases in warm countries, but their general conditions for society, as a whole, seem to be less favorable than those of colder countries.

Physical conditions are, however, less potent than social conditions in stimulating the advancement of science as well as that of art. Three conditions in social life may be mentioned as especially important in preparing the way for scientific development. First, society should be far enough advanced in numbers and in wealth to have evolved a class with opportunities to devote their time to intellectual pursuits. This condition is brought about comparatively early in society by the caste or class system, and later is made much more effective by the system of division of labor. New societies cultivate science but little because they have neither produced a leisure class nor have they extended the system of division of labor far enough to permit individuals to devote their whole time to scientific pursuits. Secondly, a society should be active, for such a society undertakes new enterprises and stimulates society through the medium of the arts. Rigid societies, such as China and India, are satisfied with past achievements in knowledge, but when such societies become active, as in the case of Japan, they feel the need of devoting themselves to the acquisition and the extension of knowledge. Thirdly, social conditions should be such that man may easily free his mind from the influences of the past. He must emancipate himself

from tradition. This is a different thing from what is commonly understood by freedom of thought. Under certain conditions men seem incapable of thinking outside of traditional ways, while under other conditions they may show great mental vigor in the face of severe persecution. As rigidly prescribed beliefs in society are usually due to the authority of religion, emancipation from theological restrictions must usually precede periods of mental activity. History gives us two well-marked periods of scientific advance, the Greek period of scientific thought and the modern period beginning in the sixteenth century, and both movements began under similar circumstances. In both cases emancipation from theological dogmas preceded scientific activity, and this emancipation was accomplished by the stimulating effects of geographical discoveries. In Greece some of the old religious myths were actually disproved by these discoveries, while belief in others was undermined by the enlarged ideas resulting from them. Similarly in modern times the intellectual life was greatly stimulated by the discovery of America and the circumnavigation of the globe; and the authority of the church was weakened by its strong opposition to the Copernican system. In 1616 the Inquisition issued an edict, which has never been repealed, declaring that to suppose the sun the center of the solar system was false and contrary to the Scriptures.[5] In the modern period of enlightenment, it is true that society was by no means stagnant when the discoveries were made; in fact, the discoveries themselves were due to an awakening intellect which may be traced to several sources, the chief of which is doubtless the travel and trade resulting from the crusades. Traced back to their source, therefore, it will be seen that the religious superstitions were themselves responsible for the movement which finally exterminated them. If the intellectual development of the Arabians is considered to be a third period of scientific growth, we shall find that that also was preceded by extended migrations and conquests, which affected greatly the active religious beliefs of the Mohammedan conquerors. The whole intellectual attitude of the Saracens changed after their conquest of Africa. Although in the three cases just cited geographical discoveries were responsible for the change in the mental attitude, no one event can be held responsible in all cases for the emancipation of the mind. If the forces of conservatism are very strong, a powerful social upheaval may be necessary to prepare the way for the reception of new truths. If, however, the intellectual condition is less rigidly fixed, milder influences may serve to stimulate thought. After scientific development has once begun, the succession of new truths themselves is the best guarantee against the excessive influences of tradition.

Ordinarily an active society will free itself from the bonds of tradi-

[5] "The Cambridge Modern History," Vol. V., p. 714.

tion. But that is not always the case, as is shown by the history of Spain during the period of intellectual activity which followed the geographical discoveries. Spain was an active country from the fourteenth to the sixteenth centuries, but its activity was not sufficient to overcome its intellectual conservatism; and this seems to be the reason why Spain took no part in the scientific progress of that period.

Professor Ward thinks the most important stimulus to the development of the mind has been the formation of the system of caste, because it produced a leisure class. A caste system is certainly important in the early stages of mental development, but such a society is likely to become conservative in its attempt to safeguard the interests of the leisure class. And when a caste system becomes rigid and traditional its usefulness is gone. If the idle class is also a priestly class, it is usually of service in preserving knowledge, but the very tenacity with which it clings to old ideas prevents it from discovering or accepting new ones. In the long run, therefore, a caste system has many disadvantages, and at no time is it so efficient in the advancement of knowledge as the system of division of labor.

Some of the conditions which help to stimulate science are also favorable to the production of art and it may be thought that all conditions favoring the two are sufficiently alike to cause science and art to develop together. But such is not always the case. Art, literature, and science developed in much the same period in France, and the same is also true of the Netherlands. Literature and science developed together in England. In the Arabian civilization also architecture, literature and science flourished simultaneously. In Italy, however, scientific activity followed art by at least a generation and it was relatively much less important. And in Spain science was almost disregarded when art and letters were cultivated with brilliant results. Furthermore, in Greece science developed at a considerably later period than art, and again in modern times science has made wonderful progress with only moderate achievements in art. The attainment of wealth and leisure is desirable for the development of both art and science and freedom from interference is essential for the best interests of both; but other circumstances may determine whether the intellect or the emotions will develop more fully. A society which is very rigid in its intellectual beliefs may produce a high grade of art in giving expression to those beliefs; or a society may encourage the fine arts while it does not develop the useful arts and hence does not give a special stimulus to the advancement of science. A wealthy luxurious upper class which may patronize the fine arts is likely to be conservative and intolerant of revolutionary discoveries. Scientific activity requires an underlying seriousness in the social life; and this was entirely lacking in Spain, for example, in the seventeenth century. On the other

hand, young societies which are active are likely to show an interest in science before they make any headway in the production of the fine arts. The appearance of art requires an economic condition which produces luxury, and a social condition which will stimulate the emotional life; while science requires economic progress which will stimulate the useful arts and a social condition which will emancipate the mind from the domination of the past.

The discussion thus far has been confined to the origin and effects of positive knowledge in general; it now remains to consider the more detailed effects upon progress of the separate sciences. The origin, or at least the early development of the sciences, may in almost every case be traced to an attempt to improve the arts or to obtain some specific object, and the chief service to society of these sciences has usually been in solving those very problems which gave them their origin. A brief account therefore of the beginnings of the leading sciences will open the way to a discussion of their effects upon social progress.

Astronomy was one of the oldest sciences to take definite form, originating it is thought in Egypt or Chaldea, although China has very old astronomical records. In Egypt the study of astronomy was probably first stimulated by the phenomenon of the overflow of the Nile, upon which Egyptian civilization depended. The exact time of this phenomenon was a matter of importance and the passage of time was most easily marked by the movement of the stars. The first study of the heavenly bodies, made in order to mark the passage of time, soon led to a more detailed study for another purpose. It was noted that the Nile began to rise with the heliacal rising of Sirius. This coincidence was easily mistaken for cause and effect and if Sirius had such an extraordinary influence upon the affairs of men, the conclusion naturally followed that other stars must also have their influences. To ascertain the amount and character of these influences led to the study of astrology, which held man's attention for so long and enlarged considerably our knowledge of the heavenly bodies. In both Chaldea and China the desire to measure time accurately, as well as the wish to forecast the future, caused a careful study of the heavenly bodies. In Phœnicia the peculiar stimulus to the study of astronomy appears to have been the desire to obtain an accurate guide for traveling either by sea or land. The accurate marking of time, the requirements of travel and the desire to know the future were therefore the chief incentives for the study of astronomy, and the first two have been of continual service to society at all times.

The fact is worth noting that astronomy developed first in desert countries where the air is clear and the stars are easily visible the greater part of the time; in pastoral countries, too, where shepherds could follow

the movements of the stars either out of curiosity, or to note the passage of time. Astronomy would have had an early origin even if it had not been for the overflow of the Nile, yet it is doubtful if it would have developed so soon under different atmospheric conditions.

The commonest laws of physics as well as the simplest movements of the heavenly bodies were known so early that we are unable to trace their sources. The Egyptians, again, were probably the first to study physical laws. The pyramid builders must have had a considerable mechanical as well as astronomical knowledge. Later engineering feats, such as the canal of Ramases and the various contrivances for controlling the waters of the Nile, would be considered creditable achievements even at the present day, and hence they show considerable advance in engineering skill and in knowledge of physical laws. Thus a knowledge of physics seems to be traceable in early times to building enterprises and engineering achievements.

In ancient times the subject of chemistry was cultivated in a practical way in the shape of metallurgy, the manufacture of colored glass and the dyeing of fabrics. But interest was early turned aside from these practical problems to the visionary one of transforming the baser metals into gold. This quest of the alchemists was begun in ancient Egypt and was continued through the middle ages until the scientific awakening of the sixteenth century. On the whole it was more of a hindrance than a help to the development of chemical knowledge. A more profitable study lay in the search for curative agents. This first took the fanciful form of a search for the elixir of life, but after the time of Paracelsus in the sixteenth century, a more scientific attitude was fostered and medicine became the chief medium for the advancement of chemical knowledge. Up to the nineteenth century the only laboratory of chemistry was the pharmacist's shop.[6] In comparatively recent times chemistry has found another incentive to progress in the desire to improve agriculture.

In their origins, chemistry and biology are more closely allied than any of the other sciences. Some knowledge of both animals and plants was of course gained in prehistoric times in the search for food. But in ancient civilizations and even down to modern times the one great stimulus to the growth of biological knowledge lay in the healing art. In ancient and medieval times almost all the contributors to biological knowledge were physicians with the possible exception of Aristotle, though it is doubtful if an exception should be made of a man who kept a pharmacy shop. At the Alexandrian museum the subjects of natural history and anatomy were carried on by the faculty of medicine, one of the four faculties originally established at the museum. In addition

[6] Wm. H. Welch, "The Interdependence of Medicine and Other Sciences of Nature," *Science*, January 10, 1908.

to medicine agriculture also forms a root for biology as well as for chemistry.

Psychology in early times had an indistinct origin in metaphysics, but as an inductive science it is of recent growth. In addition to the metaphysical problems which the study of mental processes was supposed to solve, two practical problems may be mentioned as stimulating the development of psychology. First the study and treatment of pathological mental states, which unites psychology with biology and chemistry in that all three have their origin to some extent in medicine. Secondly, the study of normal mental states and the course of mental development in order to improve the intellect and ameliorate human conditions through better methods of education.

As biology rests on the attempt to heal individual disease, so sociology arises from the desire to cure social ills and improve social relations. This statement would not be true of all the social sciences, especially economics, which found its chief incentive in the attempt to increase the material wealth of one social group at the expense of other groups. The general science of sociology, however, like that of biology, had its chief root in the desire to heal. The existence of poverty, crime, labor disputes, and similar problems has stimulated the desire to understand the principles of human association and the laws of social development.

With this brief review of the social origin of the sciences, we are prepared to consider in greater detail their effects upon social progress. In order to do this it will be advantageous to separate the sciences into three groups by diagonal lines, so to speak, the divisions not corresponding to the recognized boundaries of the different sciences. The first group includes astronomy, the greater part of physics and smaller parts of chemistry and biology. This group comprises what may be called the sciences of the environment. The second group includes a small part of physics and larger portions of chemistry, biology and psychology. This group comprises the sciences pertaining to individual life. Sociology and a part of psychology form the third group, treating of social life. If a larger number of the subsciences are included, the divisions would not be materially altered. A part of economics would be included in group one, as dealing with the environment; and a part of geology would fall into group two. These three groups may be designated for the sake of brevity as the natural sciences, the biological sciences and the social sciences, dealing respectively with the environment, with individual life, and with social life.

The historical development of the sciences is a complicated problem. Comte maintained that they developed in a serial order from the simplest to the most complex in the order of his classification—astronomy, physics, chemistry, biology and sociology. Spencer strongly opposed this theory and produced many facts to show that the serial

order could not be upheld especially in the subdivisions of a science. Although Spencer appeared to have the best of this argument, there is, nevertheless, some ground for holding to the general principle expressed in Comte's theory. Following the three-fold division of the sciences, which I have given above, it seems clear that the sciences dealing with the environment developed before those dealing with life, and the latter group developed in advance of those dealing with society. This is, moreover, the order of their present degree of advancement as well as their early development.

The development of the sciences seems, in fact, to be influenced by two conditions, first the immediate interest of men, and secondly the complexity of the phenomena investigated. These two conditions account sufficiently for the relative growth of different branches of knowledge at different times. In early stages of civilization man's attention was concentrated chiefly upon the physical environment. To get a food supply and other necessaries of life more easily, to protect themselves against their enemies, to provide for the needs of the dead, and to satisfy the demands of the gods, were all important problems which stimulated a knowledge of the environment and brought at least a practical working knowledge of the simplest laws of mathematics, astronomy and physics, together with some knowledge of minerals, and of animal and vegetable life. The phenomena of life, the desire to live indefinitely and to overcome disease, attracted attention almost as soon as problems of the environment. But life is much stranger and more complicated than those objects of nature which may be readily examined, and a positive knowledge of the phenomena of life was much more slowly acquired. The heavenly bodies and other natural objects which were so far removed that their character was not easily perceived, and living things which were so complex that they were not understood, remained objects of superstition and speculation much longer than inanimate objects close at hand. The persistence of religious superstition delayed considerably knowledge of human anatomy and disease, favoring rather the pursuit of astrology and alchemy. The anatomical studies of the Alexandrian school were in opposition to the prevalent sentiments of the time, and the Mohammedan religion hindered the study of biology, as compared with other sciences among the Arabians. Biology, therefore, developed later than the physical sciences, not because it did not attract attention, but because it was too complicated to be understood in an early stage of mental development. The social sciences, on the other hand, developed last, both because they did not attract attention at an early period and because they dealt with complex phenomena. It is true, as Spencer points out, that some practical knowledge of social organization must have appeared at a very early time and conditioned, in a sense, all forms of progress. But this kind

of knowledge was almost instinctive, and of such a nature as gregarious animals possess, or it was at least a product of gradual experience. For a long time social organization was not a subject of study like physical phenomena. Politics was the first social science to develop, if we may except ethics, which in its origin was connected with religion or philosophy, and was hardly an inductive social science. An interest in politics did not arise until different forms of social organization appeared and could be readily compared. A mere aggregation of people did not stimulate a study of politics, nor did more complicated organizations as long as they all rested on force. But when a change in social organization appeared possible, when different forms could be compared, and some were seen to be more efficient than others, social organization became an object of study. Under such conditions appeared Plato's "Republic," Aristotle's "Politics" and Machievelli's "Prince." Economics and other social sciences followed politics, but so difficult and complicated are the laws of association, that even with the present facilities for investigation, a general science of sociology can hardly be said to be established. The three comprehensive groups of sciences here outlined, seem, therefore, to have appeared in the order given in accordance with men's interests and the complexity of the phenomena to be studied; though it must be admitted that the subdivisions of the sciences did not develop according to their complexity alone. The additional influence of the immediate needs of mankind is strong enough to disturb materially Comte's theory of their historical development.

It is possible now to go a step farther and show that the growth of one group of sciences prepares the way both directly and indirectly for the growth of another group. The direct effect of the advance of one science upon others is a well-recognized fact and this influence is not by any means always in the direct order of their serial development, according to Comte's classification, but is frequently in the inverse order. A knowledge of physics has helped to advance astronomy as much as it has chemistry. This form of the interdependence of the sciences need not be enlarged upon.

The sciences have a less direct effect upon each other through the alteration of social conditions and the change of men's interests. Thus the earlier sciences have in a sense prepared the way for the later, and the development of the later sciences has often given a new impetus to the further advance of the older. The increasing knowledge of the physical sciences has produced two great results: First, it has increased man's power over nature, and, secondly, it has done much to free the mind from the bonds of superstition. The conquest of nature has increased the food supply, as well as other forms of wealth, and therefore made possible a larger population and permitted the concentration of population in small areas. This increase of population, how-

ever, which preceded an adequate knowledge of biology in the form of medical and sanitary knowledge, resulted in a high mortality rate, which is always a heavy drain on society, and therefore a great impediment to progress. Not only was the ordinary death rate high, but occasionally plagues swept over large areas making fearful havoc in the population. Authorities state that the black death in the fourteenth century took half the population of England. These pestilences were spread by the increased travel and trade made possible by the very progress which had been achieved in the control of nature. This period of the predominance of the natural sciences may be called the great period of natural selection. A denser population made possible by the increasing control of nature was held in check by a high death rate, uncontrolled because of the lack of medical knowledge. But these unfortunate conditions resulting from the unequal advancement of knowledge developed influences which were destined finally to reduce the evils. Disease and death have always seemed great enough evils to cause men to try to avoid them in more or less rational ways; but in a concentrated population these evils are brought forcibly to men's attention especially when they come in the form of a disastrous pestilence. Furthermore, increased association, which comes from a larger and denser population, is the chief means of developing sympathy and of arousing the desire to alleviate the sufferings of others. Hence the increased sympathy for others, and the more vivid realization of the amount of suffering in existence, became incentives for an increased effort to lessen the evils of disease. Moreover, other altered conditions caused these efforts to take a scientific turn. Previously superstitious beliefs had hindered the progress of science. Plagues were considered a visitation of the divine wrath, disease was treated with charms or with appeals to the saints, and the growth of anatomical knowledge was hindered by religious superstitions which forbade contact with dead bodies. But the new knowledge of the material world gradually lessened the hold of these superstitions and prepared the way for the scientific observation of the course of disease and the study of anatomy by the laboratory method.

In describing the effects of the natural sciences and the influences which have caused the development of the biological sciences, I do not mean to imply that the progress of knowledge has been continuous and uninterrupted, so that one particular period of history may be pointed out as having the conditions favorable for the origin of biology. There are a number of periods in which the forces here mentioned have been at work in greater or less degree and have influenced biological science. Perhaps at no time have they been more in evidence than at present, when, for example, modern conditions have turned people's attention to the ravages of tuberculosis, and have increased efforts to overcome

this disease; or when the havoc caused by insect pests has become so disastrous as to cause a careful study of such forms of life in order to eradicate them. These influences, so clearly at work now, have, however, been in operation in greater or less degree since the sixteenth century. They were at work also during the later period of Greek civilization and had it not been for the persistence of religious superstition they would have been effective in the Arabian civilization.

Turning now to the effects of the biological sciences, three important influences may be mentioned: First, biological knowledge, through the prevention and cure of disease, has greatly decreased the rates of mortality; secondly, through the destruction of injurious pests and through the selection and cultivation of vegetable and animal life, it has multiplied and improved the food supply, and incidentally it has increased other forms of wealth. In these two ways then the sciences of life have made possible an increase in population at least as great as that made possible by the physical sciences. But it should be noted that the biological sciences are supplementary to the physical sciences. Both stimulate the growth of population, but the biological sciences do so without the suffering and waste prevalent before their development. Neither group can do its proper work without the other and each group has been a stimulus to the growth of the other. Sanitary measures could not be carried out without engineering knowledge, the present concentration of population would be impossible without sanitary precautions, and a large food supply would be useless without rapid means of transportation and communication. Finally, biological sciences have to some extent, and will to a greater degree, improve individuals and the race through selection and education. Medical science has been severely criticized because it has counteracted the effects of natural selection by making it possible for the unfit to live and propagate their kind. Without doubt a partial knowledge of the laws of life has produced some temporary evil effects along with the good. But the remedy lies not in a return to former conditions, but in the adoption of new methods through the perfection of our knowledge. Psychology has already enabled us to make rapid strides in our system of education and in our treatment of mental diseases; and a better knowledge of the laws of heredity and improved methods of social control will enable us consciously to improve the human species in ways most advantageous. And they will accomplish this more quickly and effectively than by the blind process of natural selection.

The past century may be regarded as preeminently a period of biological discovery, not because the physical sciences have not advanced also in a marked degree, but because biological discovery is the new factor which has been added to science to influence social progress. This new factor is destined to further in a wonderful degree individual

efficiency and well being. It has already diminished human suffering and will in the future enable us to conquer some of the most serious evils still existing. But our rapid conquest of nature and our increasing control of different forms of life have introduced certain new evils which instead of being self-corrective seem likely to increase unless new forces in the shape of social sciences arise to correct them.

Mention has just been made of some of the undesirable effects of medicine in counteracting the forces of natural selection. The correction of this evil will not be found in biological science alone. A thorough study of the dependent, defective and delinquent classes must be made before an adequate reform can be begun and this study is an important department of social science. Modern ideas of humanity will never be satisfied with an indiscriminate production of dependents, soon eliminated by selective forces because they can not adapt themselves to the environment, even though the vigor of the population is kept up by this method. And the sense of self preservation will not long suffer the indiscriminate production of dependents who are kept alive as burdens upon the community and are even permitted to multiply and thus lower the average vitality and efficiency of a society. The only solution consistent with modern sentiment lies in studying the causes of the evil and applying the remedy at the source, so that fewer dependents will be produced and the average vitality of the population will be raised. This will be accomplished only through the cooperation of the sciences of individual and social life. Another evil effect of the unrestrained production of wealth and of the irrational propagation of human beings has attracted still greater attention and has probably been most influential of all in stimulating the study of sociology as a general science of society. The greater control over nature made possible by the advance of the natural and biological sciences and the increased wealth resulting therefrom, has affected different parts of society very unequally. Certain persons, who, for various reasons, had an early advantage in the accumulation of wealth, have been able to retain that advantage and even to pass it on to their descendants. In some cases, advantage once obtained has become cumulative. On the other hand the descendants of those who lacked special advantage, or were hindered with positive disadvantage, suffered similar and even greater disadvantage. And in the older societies the possibility of improvement through individual effort becomes more and more difficult. The resulting divergence of classes, which may have been useful in certain stages of social progress, is now seen to be out of harmony with the present trend of development. Society suffers because such a large number lack opportunity. Forces at work in progressive societies have, it is true, been lessening this evil, but modern sentiment now demands a more rapid change. And this desire has stimulated the study

of sociology in order that the reform, which would evidently be radical, may be made in accordance with the natural laws of growth and with as little shock as may be to the social body.

Finally the social sciences supplement the natural and biological sciences by making their work more effective. The science of politics should perfect the general social organization and promote efficiency in all kinds of collective activity. The science of economics should aid in the conquest of nature by a better direction of the agents of production and exchange and should further human efficiency and well being by improving the process of the distribution of wealth. Similarly, jurisprudence, ethics and other social sciences should help to eliminate those who seek to prey upon society and should smoothe out the social relations of the rest.

The social sciences, therefore, the last of the three groups, contribute to progress by correcting certain evils left by the other sciences, by improving social conditions, and by perfecting social organization so as to increase social and, therefore, individual efficiency.

To sum up, the natural sciences developed first, because man was first interested in the conquest of nature and the simpler physical laws could be grasped at an early period. This period brought an increase of wealth but it was wasteful of human life. The desire to save life led the way to the study of biology and this study was made possible in a scientific way because of the enlightenment which came with the spread of knowledge. Knowledge of the physical environment and of life, however, did not prevent social disease from flourishing and did not greatly improve the social condition of a large part of society. To overcome these defects the social sciences within recent years have been cultivated with great seriousness. It is true that social conditions from very early times have been such as to demand a knowledge of the social sciences, but men's interests have not turned in that direction except in one or two cases, in a limited way. Interest in the social sciences has had to wait for the enlarged sympathies and the sense of solidarity which has appeared with the growing interdependence of dense populations, and these conditions have been dependent upon the advance of the other sciences.

With the cultivation of the social sciences, then, the chain of knowledge will be complete, at least so far as the needs which have already appeared are concerned. For each group of sciences will solve one or more of the great problems which man has encountered in the process of development. The physical sciences will solve the problems of environment, the biological sciences the problems of life, and the social sciences the problems of society.

ATTEMPTS TO EXPLAIN GRAVITATION

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TO the casual observer the heavenly bodies may seem isolated; but careful study will show how closely connected they are. Not only are they much alike in composition, but across the vast gulfs separating them they hold constant intercourse. Before the time of Newton the only influence known to pass from one heavenly body to another was what we now call radiant energy. To this Newton added a second influence, the force of gravitation. To this list we may also add a third, electrical attraction. The one with which this paper deals is gravitational attraction.

To the student who has at least an elementary knowledge of physics or astronomy gravitational attraction is one of the best known properties of matter; and it can just as truly be said that it is one of the least understood properties of matter, not only by elementary students but by mature physicists and astronomers. So often has the problem of gravitation evaded solution that some in despair have doubted the ability of the human intellect to grapple successfully with it. This feeling may have been strengthened by Newton's references to himself.

At present we can't tell how one body attracts another; and the science-producing value of the efforts made to explain the mechanism of attraction is not to be judged by the prospects afforded of ultimately obtaining a solution but by the stimulus afforded in furthering thorough investigation. What we want is a hypothesis that will conform to well-known phenomena and that will stimulate further investigation. It is needless to say that final solution finds no place in our attempt.

Most of the conjectures concerning gravitation have not reached the dignity of a hypothesis. Some of them seem even too wild for a romance. I think it is Schuster who has referred to his conjectures regarding gravitation as a holiday-dream. I like this word in this connection. However since they are the best we have let us make the most of them or supplant them with better ones.

Before reciting some of the attempts to explain gravitation it might be well to refer briefly to its discovery, magnitude, peculiarities, etc. Kepler had stated in his first law that the earth revolves in an elliptical orbit with the sun at one focus. With this knowledge at hand, by strictly dynamical reasoning Newton showed that bodies attracted

according to a definite law (the attraction between two bodies being directly proportional to the product of the masses and inversely as the square of the distance, if the dimensions of the bodies are small compared with the distance between them). Having enunciated this law he proceeded to verify it by studying the motion of the moon. The moon revolves in an orbit that is nearly circular and to keep it in this orbit there must be an acceleration toward the earth equal to V^2/r where V is the moon's orbital velocity and r is the distance from the earth to the moon (approximately 240,000 miles). In place of V we may put $2\pi r/t$, where t is the time of one revolution (27.3 days). Hence the acceleration toward the earth equals

$$\frac{V^2}{r} = \frac{\left(\frac{2\pi r}{t}\right)^2}{r} = \frac{4\pi^2 r}{t^2} = \frac{4 \times 9.86 \times 240{,}000 \times 5280}{(27.3 \times 86{,}400)^2} = .0089 \text{ feet/sec}^2.$$

The acceleration the earth should exert, if Newton's law be true, at a distance of 240,000 miles (60 times the earth's radius) $= 32.16/60^2 = .0089$ feet/sec^2 where 32.16 feet/sec^2 is the acceleration at the surface of the earth. The verification in the case of the moon is complete. Hence we have the mathematical statement of the law: F (the force) $= Mm/r^2 \cdot G$ where G is a constant depending upon units only. We say nothing about the *quality* of the matter but only the *quantity,* and the *distance.* Notice also that there is no factor in the equation referring to the nature of the intervening medium.

It may not be out of place to call attention to the universality of the law. There are a few slight discrepancies between observed and calculated values, but as a whole it is fully attested by observation.

In referring to the magnitude of gravitational force consider first small bodies and later astronomical bodies. We know to-day that the radiation from the sun exerts a pressure. Kepler suggested this three centuries ago and one hundred and fifty years later the great mathematician Euler adopted his suggestion in accounting for the repulsion of comets' tails. So delicate is this pressure that it was not discovered until recently (1900). Albeit this pressure is very small as bodies diminish in size, we reach a limit at which it predominates over gravitation. This is due to the fact that gravitation is proportional to the mass (the cube of the linear dimension) while radiation-pressure is proportional to the surface (the square of the linear dimension).

When we consider electrons we find that the gravitational attraction between two electrons is insignificant compared with electrical attraction. The electrical force in air between two negative electrons one centimeter apart is equal to $(4.5 \times 10^{-10})^2 = 20 \times 10^{-20}$ dynes, if we take the charge on an electron to be 4.5×10^{-10} c.g.s. electrostatic units.

The gravitational attraction between two electrons at a distance of one centimeter $= 10^{-27} \times 10^{-27} \times 6.6 \times 10^{-8} = 6.6 \times 10^{-62}$ dynes,

where 10^{-27} is the mass of a negative electron and 6.6×10^{-8} is the gravitational constant in the c.g.s. system. Comparing the two results, we see that the former is 10^{42} times the latter.

In astronomical bodies gravitation is the predominant force. An idea of its magnitude can be gained by calculating the attraction between the earth and the moon, which are small bodies astronomically speaking. The earth's mass is about 6 times 10^{21} tons, which is 80 times the moon's mass, and the distance between the two is about sixty times the earth's radius; hence the attraction $= 6 \times 10^{21} \cdot 1/80 \cdot 1/60^2 = 2 \times 10^{16}$ tons of force. To hold this system while it rotates about a common center would require about five million-million steel bars each one foot square and of tensile strength of thirty tons per square inch. Knowing the distance between the earth and the sun (23,000 times the earth's radius) and that the sun is about 330,000 times as massive as the earth, in like manner we can show that the force between the earth and the sun is greater than that of the earth and the moon. What must it be for double stars! Surely the origin of such gigantic forces ought to be worth careful study.

When Priestley and later Coulomb enunciated the law of electrical attraction (inversely as the square of the distance) they ignored the intervening medium. It was shown by Henry Cavendish, although not published, and discovered independently by Faraday that the electrical attraction depends upon the nature of the medium. If we take a piece of glass having a specific inductive capacity of six and separate two charges by this glass the force between them is only one sixth of what it is when they are separated by the same thickness of air. Strange to say gravitation is not affected by the intervening medium. This may be due to the gossamery nature of matter; that is, that the size of the molecules is very small compared with the distance between them.

So far as we are aware, chemical action, temperature and change of state are without effect on gravitation. No one has succeeded in demonstrating that it takes time for its propagation. If it is propagated in time the rapidity far exceeds that of light.

If we have two bodies electrically charged in a field and introduce a third body there is a redistribution. There is nothing analogous to this in gravitation, for the introduction of a third body in no way lessens the attraction between the other two. The earth's attraction is the same for me whether alone or in a crowd.

Thus when we compare gravitation with other phenomena about which at least we know a little, so great are the dissimilarities that it seems almost to fall outside the bounds of the physical realm.

Having briefly touched the discovery, law, magnitude, characteristics and peculiarities, we are ready to review the attempted explanations of the mechanism.

One familiar with modern electrical theories knows that the present tendency is to include everything in the electromagnetic scheme. Maxwell started this when he promulgated the electromagnetic theory of light. Experiment by Kauffman on the beta rays of radium lead us to regard mass as electromagnetic. Hence it is very natural to try to explain gravitation as an ether-phenomenon. This would require that the ether be capable of supporting enormous pressure or tension. In the older views the ether was regarded as a very attenuated medium. Such an ether can hardly meet the demands. Many modern physicists regard the ether as very rigid and dense when compared with ordinary matter. See Lodge's "The Ether of Space." If we follow Sir J. J. Thomson, who regards all mass as mass of the ether,[1] we can calculate the density of the ether, for the mass of an electron is about 10^{-27} grams and the volume is of the order of 10^{-39} cubic centimeters; hence the density of the ether is 10^{12} or a million million times that of water. When we consider the rapidity with which an ether disturbance is transmitted we see that the rigidity should be very great compared with ordinary matter. Taking the density of ether as 10^{12} and the velocity of ether waves as 3×10^{10} cms. per sec. the rigidity will be of the order of 10^{33} dynes per sq. cm., since $\text{velocity} = \sqrt{\frac{\text{elasticity}}{\text{density}}}$. The intrinsic energy if due to rotational motion will be of the order of 10^{32} ergs per cubic centimeter, if we assume the velocity of rotation is of the order of that of light; since the energy $= \frac{1}{2}$ mass times velocity^2, where the mass of a cubic centimeter is 10^{12} grams and the velocity is 3×10^{10} cms. per sec. Hence the intrinsic energy and rigidity of the ether will probably meet the demands if we accept the views of ether and matter held by some of the greatest modern physicists.

If a falling body does not gather its energy from the ether where does it get it? Lift a ton to the height of 1,000 feet above the earth's surface and we have 2,000,000 foot-pounds of potential energy, or preferably a body that in returning to its original position will gather 2,000,000 foot-pounds of energy. Is this energy inherent in the body? Newton's letter to Bentley shows us that he was opposed to such a view. One thing is sure, there is no perceptible change in the mass and chemical composition of the body at the height of a thousand feet.

In the "Principia" Newton makes no attempt to explain gravitation, but in one of his optical queries he writes thus: "If the pressure in the medium is less in the neighborhood of dense bodies than at a greater distance from them, dense bodies will be drawn toward each other, obeying the law of gravitation if diminution of pressure is inversely as the distance."

Hooke, a contemporary of Newton and a man of great ingenuity,

[1] See Silliman, "Lectures," p. 51.

attempted a wave theory of gravitation from his observation that bodies floating on water agitated by waves were drawn toward the center of disturbance. The action of a body immersed in water was not considered. Since his time various attempts have been made to explain gravitation as due to a wave-motion. At the last meeting of the American Association for the Advancement of Science, Mr. Brush, of Cleveland, Ohio, presented a paper[2] in which he accounts for gravitation by ether-waves. His theory was doubtless suggested by radiation pressure. His theory demands an ether possessed of intrinsic energy. As before stated, the views of many modern physicists permit this. He assumes that this energy is due to waves; but the frequency is so much less than that of heat or light that molecules will not respond; and hence bodies do not become warm. He thinks that the energy of the ether is a generalized type whose degradation has been brought about by repeated absorptions and remissions. To substantiate this view he cites the case of the earth and the sun, in which rays of one length are absorbed by the earth and longer ones are emitted. He accepts the view of J. J. Thomson that all energy is kinetic energy of the ether. Before attempting to explain the mechanism of gravitational attraction he paves the way by referring to a well-known phenomenon in light. If we take an opaque body in a room with luminous walls it will experience pressure on all sides because we now know that light-waves have both energy and momentum. If we now introduce a second body each will be in the shadow of the other or will screen the other; and hence the radiation pressure is less on the side of each body which faces the other; and hence there will be a tendency for the bodies to be *pushed* together.

Now substitute for the light-waves waves of great length and less frequency, and owing to their low frequency they will affect the interior molecules as well as the surface ones, and hence we will have a volume or mass effect and not a surface effect as in light. This is in accord with Newton's law, for the force is proportional to the mass. "We may picture . . . molecules of matter buffeted about in every direction by ether-waves in which they are entangled, like a suspended precipitate in turbulent water." Now introduce a second body and the pressure in the direction of the line joining these two is less than in any other direction, as each is in the 'shadow' of the other; hence they are *pushed* together. Notice that according to his theory gravity is not a tension, but a pressure. Mr. Brush's theory, like all other theories regarding gravitation, is beset with difficulties. If gravitation is due to a type of radiation transmitted at finite speed it ought to be subject to aberration as is light. To avoid this Brush takes longitudinal waves and assumes the elasticity of ether is such that their velocity is much greater than that of light waves which are transverse. Longitudinal waves in the ether

[2] See *Science*, March 10, 1911.

have not yet been detected. However, this is no final argument against their existence as new and striking discoveries are being made every year. These longitudinal waves force us to conclude that the ether is at least slightly compressible. If compressible we are inclined, from our knowledge of matter to think of the ether as discrete or molecular. If discrete the particles are elastic and we have to postulate a second ether to explain the elasticity of the molecules of the first. This destroys the simplicity of the ether.

J. J. Thomson in his Silliman Lectures (page 160) enunciates a view somewhat similar to that given by Brush. In place of longitudinal waves he used short ether-pulses something like the Röntgen and gamma rays are supposed to be. This view presents the aberrational difficulty, as do other views which attempt to explain gravitation by a type of radiation. On this view any change in gravitation would be propagated with the velocity of light; and certain phenomena in astronomy require the gravitational effect to be propagated much faster than light.

Near the beginning of the paper we showed that the gravitative attraction between small charged bodies is very small compared with the electrical effects. Now if we assume that the linear equations of the ether are only approximate we may account for this relatively small gravitational effect from terms involving differentials of second or higher orders. Larmor[3] opposes this view because the introduction of higher order term not only disturbs the simplicity of the ether scheme, but also leads to optical dispersion in free space. If such dispersion exists it must be very minute, as bodies emerging from eclipses show no appreciable change in color. However, when we compare the gravitational force with the electrical force we see the former is so very small that the higher order term introduced to account for gravitation might give us a dispersion too minute for observation. But, as usual, we meet insurmountable difficulties. On this view the velocity of transmission would be of the same order as that of light; and while we do not know whether the speed is finite at all, we do know that if it is finite it greatly exceeds that of light.

Hence at present gravitation seems to be precluded from the electromagnetic scheme, owing to speed of propagation. Since in the last ten years we have tried to unify, it is unfortunate that it rebels against admission into our scheme. Many have pronounced it a mode of activity in the ether not specified but entirely different from the electromagnetic mode.

Replace Brush's long waves or Thomson's short electromagnetic pulse by rapidly moving corpuscles and we have Le Sage's theory. According to Le Sage space is filled with minute particles, ultramundane corpuscles, moving rapidly in all directions; hence a single body experi-

[3] See "Ether and Matter," p. 187.

ences an impetus on all sides; but if we take two bodies each screens the other and they are *pushed* together. Notice the force is one of pressure and not of tension. At first sight the impulse due to the impact would seem to be proportional to the effective area whereas according to Newton's law it ought to be proportional to the mass; but when we compare the diameter of a molecule with the distance between molecules, we see that only a small portion of the particles are arrested and that the number arrested is proportional to the number of molecules in the body (the mass).

The objections to Le Sage's theory are almost too numerous to mention. First and foremost, the enormous speed at which these corpuscles must travel not to resist planetary motion involves an enormous supply of energy from a source outside our universe. On this theory the source of gravitation is ultramundane. Again if these corpuscles are elastic there would be no screening action on the part of a body as the corpuscles would carry away their energy in reflexion. If the corpuscles are inelastic, bodies ought to increase in size. As the corpuscles transfer their momentum to bodies they lose kinetic energy, and according to Maxwell the loss sufficient to account for gravitation if converted into heat would keep the body white hot. Sir J. J. Thomson has shown that it is not necessary to suppose the energy is transformed into heat. In place of heat rays he suggests that the particles might give rise to a very penetrating radiation just as the cathode particles are supposed to give rise to the short ether-pulse known as Röntgen rays.

The fact that a physicist of Kelvin's rank has tried to patch up a theory that is so superficial shows how hard put to we are when we attempt to explain gravitational attraction.

About thirty years ago Zöllner explained gravitation on the assumption that the molecules carry positive and negative charges and the attraction between two unlike charges exceeds the repulsion between like charges. Lorentz, assuming a neutral body to be an assemblage of positive and negative electrons, has used the same hypothesis.

At Cambridge University during the fall term of 1908, Sir J. J. Thomson gave a course of lectures on "Ether and Matter" and in that course he devoted about three lectures to gravitation. Take two charged plates and in place of drawing the resultant Faraday lines of force (a Faraday line is a line beginning on a unit positive charge and terminating on a unit negative charge) consider the components (see Fig. 1).

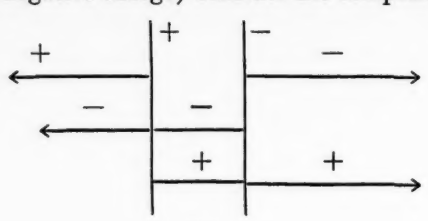

FIG. 1.

Outside the plates we have opposite effects in the same direction, hence they annul. Between the plates we have opposite effects in opposite directions and the effects are equivalent and hence cumulative. The tension will depend upon the number of lines and the closeness together. Each positive line will increase the tension of a positive line and a negative line will diminish the tension of a positive line. If a positive line increases the tension of a positive line just as much as a negative line decreases it, and if a negative increases the tension of a negative just as much as a positive decreases it, then the resultant tension between the plates will be zero, since there are just as many positive as negative lines. But if the effect (increase) of a positive on a positive is not the same as a negative on a positive there will be a resultant tension between the plates.

Now take an unelectrified body which we consider an assemblage of positive and negative charges. Lines of force will start on the positive charges and terminate on the negative ones, and just as there was a tension between the plates if the effect of a positive on a positive was not the same as a negative on a negative, so there will be a tension around this unelectrified body, if the above is true. Hence by making the assumption that the lines of force from a positive charge are not the same as those from a negative charge, the increase in tension of a positive on a positive is not the same as the decrease of a negative on a positive and we shall have a resulting tension. This might give rise to forces in the body of which the most important is gravitation. Here are Professor Thomson's own words taken from my class notes: "Matter I regard as made up of positive and negative charges. . . . Each unit charge is the termination of a line of force. I do not regard the positive and negative lines side by side as the same."

If you are looking for a Herculean task put the theory to test. Before starting let me remind you that the effect of the earth's field on an electron is something like 30 million times that of gravity and that it is not easy to screen a magnetic force. We see then that this theory is beset with difficulties before which the experimenter at present is helpless. Again, it complicates the simplicity of the electronic theory of electricity. Again, electrical attraction depends upon the medium. On this theory should not gravitational attraction also depend upon the medium? A summary of Professor Thomson's lectures on gravitation was published in Cambridge Philosophical Society Proceedings during the spring of 1909.

Various other theories have been promulgated but they must be passed by. Those interested in the subject will want to read Osborne Reynold's theory. Kelvin's hydrodynamical theory, which involves both the creation and destruction of matter, is rather unique.

Some despairing of ever finding a physical explanation have taken

hold of Riemann's idea of space as a manifold. As this is wholly extra-physical and not in my realm I shall do no more than mention it.

Thus the phenomenon of gravitation remains a mystery; for so far every hypothesis made seems to have insurmountable difficulties. I am not sure that any of them shed light enough to even convince us that we are on the right track. It seems to have little or nothing in common with various other things of which we have some knowledge. A few years ago when radio-active substances were discovered, we found phenomena which at first did not seem to agree with well-known chemical and physical laws; but as experimentation progressed confirmation became more general and to-day many, if not all, the discrepancies have disappeared. Not so with gravitation. It still remains one of the least understood properties of matter. Probably if we could learn something of the mechanism of gravitation, that attraction between particles which only manifests itself at very small distances (cohesion) might be better understood.

Nearly two hundred and fifty years ago one of the greatest intellects connected with science turned his attention to gravitation. In that two hundred and fifty years physical science has made rapid advances. A boy who has completed a year's work in elementary physics could entertain Newton in electricity were it possible for the great philosopher to return to earth. After learning of the great progress in electricity, I can imagine him in his eager desire for knowledge turning to the boy and expecting some light on gravitation. Alas, not only the high school boy, but not even the most learned can give any definite information on gravitation. The problem is about where Newton left it.

THE PURPOSE AND SOME PRINCIPLES OF SYSTEMATIC ZOOLOGY

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SOME months ago, I had the opportunity of examining at my leisure an unpublished manuscript, dealing with a group of animals with which my own studies have made me familiar. At the same time, I had occasion to consult in connection with my work two publications, by different authors, concerning related, though not identical groups of animals. The contrasts offered by the three writers were so remarkable that numerous questions were raised in my mind, as to the motives that led to the investigations, and the principles that had governed them. So far as I can see, each paper may properly be classed as a contribution to systematic zoology and yet the three are totally unlike. In one of the published papers, the writer is wholly occupied with questions of names. He produces evidence to show that a given name is of earlier date than hitherto supposed, another is preoccupied, another was never properly defined, and still others have been erroneously used. Even though the results are disturbing, the facts brought out are interesting and the methods used are clever, but the questions arose in my mind—Is this zoology? Or is it history? Or what is it?—The other publication was utterly different. The author eschewed books entirely. He gave a series of descriptions of a number of what he designated as new species. The names he had given them were above reproach. The descriptions appeared to be lucid. The measurements seemed to be accurate. The locality from which each species came was given with more or less exactitude. But that was all! Not one species was commented on in any way. Not one was compared with any other. There was no more apparent connection between them than that between the books of a dealer's catalogue. And again the question forced itself on me—Is *this* zoology?—The manuscript which I examined was strikingly different from either of the published articles and yet it certainly had features in common with each of them. There were frequent references to books and names, there were descriptions of new species, and in neither respect did the writer show greater learning or skill than the authors mentioned. Yet the significance of structures and the interrelationships of the species were so illuminatingly treated that I never felt any doubt that the work was really zoology, or that any zoologist would fail to ac-

knowledge its value. But the point of view and the methods of the writer seemed so different from those of the other authors, that this question arose in my mind—Is it fair to call such work systematic zoology? And so, naturally, I fell to considering the purpose of systematic zoology and the principles which should govern it.

A century ago any one who was a zoologist was, almost of necessity, a systematist. Although Lamarck is now perhaps best known for his contribution to philosophical zoology, he was preeminent in his day as a systematic zoologist, and in some groups of invertebrates his work may be regarded as forming in large part, if not wholly, the foundation of our present classification. So too Cuvier, famed as a comparative anatomist, left as his chief monument, the great systematic work, "Le Règne Animal," in which the results of his anatomical studies were fittingly summarized. But in the days of Lamarck and Cuvier, as Agassiz pointed out in his "Essay on Classification," the fauna of Europe, so far as the larger animals were concerned, became so well known that men with a love for zoology, but without means of securing collections from foreign lands and not attracted by the minute forms of life, turned from the describing and classifying of animals to a more intensive study of those already well known. Not only did anatomy receive more adequate attention, but the habits of animals and their relation to their environment became subjects of investigation, while under the inspiring leadership of Döllinger and von Baer, embryology, virtually a new field, was opened to investigators. Then came the days of Lyell, Agassiz, Darwin, Wallace and their many illustrious contemporaries, and zoologists began to realize the magnitude of their field and the multiplicity of its problems. No such sudden enlargement of the field for zoological research had ever occurred before and probably never will again. It was natural, therefore, that many zoologists working on the frontiers of the new territory should not merely lose sight of their fellows, who had not traveled so far, or who had journeyed in different directions, but should also lose sympathy with them. Although the lazy, the easy-going, the incompetent, do as a rule lag behind when a new country is opened, those who remain in the old fields do not usually do so from laziness or incompetence, Charlatans and self-seekers are conspicuous in frontier communities, but, of course, the majority of those at the front are not such. A man's motives may be the highest and the quality of his work the best, regardless of whether he remains in the old fields or seeks to push the frontier further on. In any case, however, he should know what he is trying to do and why he is trying to do it. He should be ready and willing to give a reason for the faith that is in him—faith that the work he is doing ought to be done and that it is *his* work. It is eminently fitting, therefore, that we who are still busied with systematic zoology should make

clear our central purpose and formulate some of the principles that guide us in our work. In attempting to do this, I am obviously speaking only for myself. I could not, even if I would, express another worker's motives or principles. The excuse for publishing my own is two-fold; the thought that they may be in some way suggestive to other systematists, and the larger hope that they may serve to increase the mutual sympathy between all classes of zoologists.

There seem to be at least three current opinions as to systematic zoology. One is that it is engaged in the vast undertaking of cataloguing the animal kingdom. Every species of animal must be listed and hence must have a name, or, at least, a number. That the names may be attached to the right animals, descriptions and figures must be published. As there are still an unknown number of unnamed species, the describing of new species is the most important part of systematic work. The remainder consists of arranging in some sort of comprehensible system the thousands of names already in use. This type of systematic work is well shown in Linné's " Systema Naturæ," the purpose of which is, frankly, to give a complete catalogue of all natural objects. The confidence that such a catalogue would be immensely useful for many purposes was a sufficient incentive to undertake the labor involved.

A second opinion of systematic zoology, which has found expression several times since the opening of the twentieth century, is at the other extreme from the preceding. This very modern view is that systematic zoology covers the whole field—morphology, physiology, embryology, histology, paleozoology, even cytology are but assistants in systematic work. As taxonomic characters occur obviously on the exterior, so they occur no less really, though obscurely, in the internal structure, in the performance of functions, in the tissues, in the development, even in the mitotic figures in the cells. As comparative study of recent animals is essential to a proper understanding of character values, so the careful study of fossils and the revelations of the geological record are supremely important for systematic work. According to this view, the systematist is not the assistant erecting the scaffolding with the aid of which the real building is to be done by the other specialists, but he is himself the master-builder and the others are the carriers of material with which he may build.

The third opinion of systematic work, held in some degree by many zoologists, though often more or less unconsciously and seldom openly avowed, is that it forms an elementary sort of study which has a certain educational value in training the eye and the judgment of those who are to become zoologists. It bears much the same relation to zoology proper that arithmetic does to what we call higher mathematics, and the really able man will not delay in it, after he has secured the training

it affords. It is preeminently the field for the amateur and the untrained worker. According to this view, a piece of systematic work may well be a part of the training of all professional zoologists, but capable men will naturally go on into the supposedly more fertile fields of physiology, cytology and experimental zoology.

As is usually the case where diverse opinions clash, a measure of truth is to be found in each one of the above-mentioned three, and doubtless there are other views more or less equally true, to which I have given no expression. As a systematist I should be very glad if I could bring myself to believe that the second view, formulated above, is essentially correct but the more I have thought on the subject the more strongly I have felt that it claims too much. It juggles with words and distorts some inescapable facts. On the other hand, every systematist whose zoological horizon is not hopelessly limited must reject the first view as utterly inadequate, while he will very naturally resent the implications of the third. There can be no question that so far as it goes the first view is true; naming species and cataloguing them, and even determining the correct names to use, are a conspicuous part of systematic work still. If, however, the systematist goes no further, he can not expect high rank as a zoologist. He ought not to ignore the significance of his observed facts; he ought to welcome, even if he can not seek for, information from each and every part of the field of zoology. If he neglects or refuses to listen to the suggestions of physiology, embryology or paleontology, he is not worthy of his task. And this, it seems to me, is the very real truth in the second view mentioned. In the third view, the vital fact is that good systematic work requires more than ordinary training of the abilities to see, and to estimate the relative worth of the facts observed. It errs in assuming that a mind so trained can not find an adequate field of usefulness in systematic zoology.

Combining the above-given truths, we find we are still far from expressing the central purpose of systematic zoology. We have only brought together a statement of certain means to be used, of certain sources of material and of certain abilities required. The end in view is hardly suggested. As the purpose of zoology is something beyond the mere knowledge of all the phenomena of animal life, seeking further the true interpretation of those phenomena and even further to the ultimate interpretation of life itself, so it seems to me, the purpose of systematic zoology reaches beyond the mere increasing of our knowledge of animal forms and seeks a true interpretation of the resemblances and differences which we find among them. Primarily, however, it deals with results and is only indirectly concerned with the methods by which those results have been attained. It deals with the travelers, the routes traveled and the destinations reached in the animal kingdom,

but it leaves for other zoologists to determine the means of transportation and the causes of the traveling. Briefly we may express the motive thus:

The purpose of systematic zoology is to determine the racial characteristics, and to set forth clearly the mutual interrelationships of animals.

The validity of this statement will not be affected, I think, by either the size of the group with which the systematist may deal, or the phase of the subject which specially interests him. It applies just as well to the man who specializes in a single genus as to him who attempts to comprehend a whole order or class. The only difference is that the smaller the group, the more the worker may hope to attain his purpose, at least to some degree. The larger the group the less is it possible for the purpose to be attained. Nor does it matter whether the systematist is especially interested in new species, or in the morphology or life histories of old ones, or in the geographical or geological distribution of animals. If his purpose is to determine more accurately the racial characteristics, or to make more clear the interrelationships, of the animals with which he deals, the value of his work as systematic zoology, at least so far as it is reliable, can not be questioned. And should the day ever dawn when it can be fairly said that the purpose of systematic zoology, here formulated, has been attained, we shall have, not merely a complete catalogue, but a complete history of the animal kingdom.

Having thus defined what seems to me the purpose of systematic zoology, I hope I may be pardoned if I attempt to formulate some of the principles which it seems to me ought to govern such work. And I may say at the outset that few inexperienced workers appreciate the difficulties involved. It is no uncommon thing to hear systematic work and workers severely criticized for the instability and uncertainty of their results. Such critics forget that nature is essentially unstable and that the fundamental difficulty of the systematist is the continual variation of the material with which he deals. No doubt much descriptive work has been poorly done and unfortunately it is true that in the past some systematists have ignored their predecessors and their colleagues. But at the present day descriptive work is, as a rule, well done and is often accompanied by most accurate figures, while ignoring the work of others is remarkably uncommon and is very rarely intentional. Nature, however, is as variable as ever and the best of descriptions and figures can not deal adequately with her marvelous diversity. Moreover, in addition to the inherent difficulty of variation in his material, the systematist has to face the even more exasperating difficulty of variation in human judgment. Not only do the judgments of his non-systematic colleagues differ from his own, but on any given point the best trained students of his particular group are quite likely to differ from him and

from each other. Still worse is the indubitable fact that his own judgment varies. What seems to him well-established at one time may a few months later be incredible, not so much because of new facts bearing on the matter, but because his horizon has enlarged or his point of view become fundamentally changed. As long as nature and human judgment are what they are, it is hopeless to look for perfect stability even in as artificial a thing as nomenclature, except by arbitrary decisions adopted by practically unanimous consent. No code can be devised which will meet all the needs of the case, and most zoologists will continue to call a holothurian a holothurian in spite of the codes, until it is arbitrarily agreed to call it something else. I can not see that the proposed substitution of numbers for names would tend to either greater simplicity, intelligibility or stability. The difficulty is not with the names we have given, but with the objects we have named and the judgments which interpret our definitions. Recognizing then these two fundamental difficulties at the very base of systematic work, I venture to suggest a few principles which would, I think, if universally adopted, increase the clarity and stability of our results. They are more or less generally accepted even now, and I claim no originality in setting them forth. I only hope their formulation may lead to more extended recognition. The first one may be expressed thus:

Naming and describing new species and correcting nomenclatural errors, while valuable and indeed essential, is frankly the most elementary and hence the lowest form of zoology.

The zoologist who, like myself, enjoys collections and finds an unceasing interest in the diversity of animal forms, very easily overlooks this principle, though he will rarely question it when fairly stated. He will grant that after all, names are but handles by which the ever-increasing number of animal units may be shifted and turned and made use of in zoological building, and he will probably admit that the handle is not so important as the unit. It would be well if we went further and acted on the principle that the smoother a handle is and the more perfectly it is adapted to its object, the better and more usable it is. A clumsy name or a meaningless name or a name that has no natural and inherent association with the object is not a desirable name, for it is not a well-formed handle. This is why, in my judgment, the use of the names of persons for zoological units is to be deplored. They rarely have any inherent association with the object, and after a short time they have no significance whatever. Any one looking at the animal can see why a certain oddly shaped sand-dollar was called *Rotula dentata,* but how many of us know who Rumphius was that the same animal should have been called by another writer *Rotula rumphii?* The use of place-names has more justification, especially for insular or local forms, but it has led to many meaningless or misleading names

and is seldom to be recommended. There can be no doubt that badly formed and inappropriate names have been a just cause of much of the criticism of systematic work. The correcting of errors is always an ungracious task, especially where the errors are apparently trivial and obviously unintentional, and this is particularly true in systematic zoology. No reasonable person will, however, question the necessity of it or refuse to accept the correction if it is justified. But in such work, accuracy of statement, soundness of judgment, clearness of reasoning and perfect courtesy are required to an unusual degree. These qualities are, of course, essential for the best scientific work of any kind, but they are particularly so in systematic zoology, where so much work is of an elementary nature. The lack of one or more of them has depreciated the value of many an elaborate monograph. On the other hand, their presence does not alone guarantee the worth of a piece of zoological research. And this suggests the second principle I desire to emphasize.

To be of real worth and permanent value, the systematic study of any group of animals must take into account, so far as they are known, the pre- and post-natal development, the geological history and the geographical distribution of the species which compose it.

A systematic study of any group of animals which considers only the adults, even if the morphology, physiology and habits are all taken into account, can not be regarded as complete. Nature would indeed be a puzzle and interrelationships a hopeless snarl, if the stages of development were not discoverable or were meaningless. It is incredible to me that any zoologist, who has examined the evidence at all, can deny the existence of stages in both pre- and post-natal development or question the fact that those stages have some meaning. And I am unable to believe that we can even approximate the true history of any group of animals so long as those stages are ignored. Equally important is the paleontological evidence and to ignore it when it exists in any appreciable amount is indefensible and may result in deplorable error. For some reason the relationship of systematic zoology to geographical distribution has been more generally recognized than its relation to paleontology, but it seems to me obvious that in the diversification of the animal kingdom, the element of time has been fully as important as that of space. In neither case, however, is it justifiable to assume that quantity (of either time or space) is necessarily correlated with specific qualities. Discontinuous distribution, either geologically or geographically, ought never to be regarded by itself as a differential character. Either may be used as an additional character for a group otherwise structurally distinguishable, but no species (or other group) ought ever to be recognized whose identity can not be determined without knowing the locality or the geological horizon from which it came. To act on any other principle can not fail to lead to

serious confusion. In view of all the evidence then which must be taken into account, it is clear that the final decision on the validity of any group must be rendered by the systematic workers in the larger group to which it belongs. It is not to be expected that physiologists or experimental zoologists or even entomologists can decide as to either the validity of a species of sea-urchin or the desirability of a genus of birds. And this leads to a third principle often overlooked.

While genera and larger groups in our systems of classification ought to be based on relationship, their delimitation is often of necessity artificial and is purely a matter of expediency or convenience.

The English zoologist Duncan maintained that it is "impossible to admit genera which are not differentiated by characters which have a decided and important physiological value." Other zoologists have ignored or distinctly repudiated this view. The difference of opinion seems to be based on a difference in the approach to the question and it is to this same difference of approach that all discussion as to the relative merits of large and small genera is due. The zoologist who is particularly occupied with the diversity of species and who has examined large numbers of individuals in the attempt to establish specific limits becomes impressed with the great importance of constancy in any given character and, when he finds a group of species which possess in common a character, or certain characters, constantly maintained, he finds it desirable to designate them by a common name and the group is to him a genus. Such a process naturally leads to numerous small genera. On the other hand, the zoologist who studies, from the morphologist's view point, relatively few specimens, representing perhaps many species, is naturally most impressed by the resemblances, and he finds that as regards characters which to him seem of physiological importance, his material divides into comparatively few groups. These he designates as genera and since the minor characters reveal a more or less marked differentiation into species his genera are naturally large. It seems to me that the difficulty is the same as would arise were one trying to decide what is a branchlet on a tree. In certain old, nearly dead trees, or in very young ones, there might be little difficulty, main branches, secondary branches, branchlets and twigs would all be sufficiently few to be distinguishable and there would be little disagreement as to the limits of the branchlets. But in most trees this would not be the case and much would depend on whether one began at the twigs and worked downward or at the branch and worked upward. In other words, while genera are, or at least ought to be, natural groups, their limits are often necessarily artificial and arbitrary. We recognize them by name for convenience and their limitation is largely to be determined by expediency. To say, as Duncan does, that it is "impossible" to recognize certain

genera is an exaggeration, however inexpedient we may deem such genera to be. Wherever the number of species in a genus is, by the extension of our knowledge, so increased as to make the group unwieldy and more or less heterogeneous, it may for convenience be divided. Whether such divisions are called genera or subgenera is again only a matter of expediency, but for my part I have never been able to see the merit of subgenera. If a group of species is not marked by sufficiently constant characters to make it recognizable, it is not entitled to a name, and if it is so marked, I fail to see why it should not be called a genus. I do not think the description of a tree would be made more lucid by an attempt to recognize sub-branchlets. It is true that the extensive use of subgenera would permit a corresponding decrease in generic names, but I do not think this would be any real advantage. We may as well face the fact that it is no longer possible for any one man, unless he be rarely gifted with the right sort of a memory, to know the principal genera of all classes of animals. Our knowledge of the animal kingdom has so expanded in the last thirty years, that even if a man specializes in the most elementary form of systematic zoology, he can not hope to have a comprehensive view of all known genera. No one will deny that this is to be regretted, but while the fault may be in part due to our systems of nomenclature, the chief blame must rest on nature and the curiosity of zoologists. The diversity of animal life and the zoologist's insatiable desire to continually increase our knowledge thereof are at the root of the trouble. It has been said that the general lack of interest in natural history among the people at large is due to our complex nomenclatural system. I doubt if interest in natural history is any less now than it has been in the past, but if it is I do not believe the fault is with our nomenclature. Granting, however, that it is, I do not see how the difficulty can be avoided. When we are told that the would-be naturalist knows a robin as *Turdus migratorius* and it is unfair to him to so divide *Turdus* that the robin has to be called by some other name, we can only reply that the inconvenience and annoyance of giving up the old name are obvious, but the progress of our knowledge of thrushes in their specific diversity has shown that the robin, when compared with the original species of the genus, is not a *Turdus,* and it is therefore inaccurate, to say the least, to continue to use that name. And in scientific work to be inaccurate is a more serious fault than to be annoying. The importance of accuracy in systematic work suggests a fourth principle which may be expressed as follows:

The value of a character for distinguishing species or higher groups depends chiefly on its constancy, and for indicating relationships within a group on its significance; in neither case is its conspicuousness anything more than a matter of convenience.

Few zoologists realize that the usefulness to the systematist of any characteristic of an animal depends on the end in view. Since species are the units with which our work is chiefly done, their most usable characters are those which will readily distinguish them from each other. But when we try to arrange them in genera and show the natural interrelationships of any group, the characters in which they are alike are of far more importance than those in which they differ. For defining species then we are often justified in using characters which seem to us trivial and of no significance. Not infrequently newly proposed species are condemned because the characters on which they are based are said to be "so trivial." When this criticism is examined, however, it will be found that it really confuses two very different things which may be illustrated as follows. A newly described bird is said to differ from another species in having the iris white instead of brown and the tail feathers tipped with cream-color instead of yellow. Such differences are certainly trivial, but experience has taught us that the color of the iris rarely, if ever, shows such a degree of diversity within a single species, and if the examination of a fair amount of material shows the two characters given to be constant, the validity of the species can hardly be questioned. If, however, the new bird is said to be characterized by a longer bill, a more markedly yellow tinge below and a greater amount of yellow on the tail feathers, these characters would not only be considered trivial but we should be justified in being skeptical of the validity of the species because experience has taught us that such characters are subject to very great diversity. If new species are to be condemned, then accuracy demands that it shall not be because the characters assigned are trivial, but because they are inconstant and hence unreliable. When we come to genera, however, while it is of course desirable that the characters should not be trivial in any sense, the essential point is that they should have some significance, either historical or physiological. These two terms are not synonymous, for such a structure as the vermiform appendix in man has a historical, though apparently not a physiological, significance. Usually, significant characters are more or less conspicuous, and I am strongly inclined to believe that where they are internal, or otherwise difficult to ascertain, they are associated with external, or in some way obvious, characters. The formation of genera based on larval characters, or those of some other special stage of development, is greatly to be deplored, and I have no doubt that if such groups really represent natural relationships, differential characters will be found in the adults. If they are not, it seems to me clear that, notwithstanding the possibilities of what we call "parallelism" and "convergence," the characters of the special stage are temporary adaptations of variable significance. It is impossible to designate any

character or group of characters which may be relied on for systematic purposes in all groups of animals. Certain characters of remarkable constancy or obvious significance in some groups are quite unreliable in others. Color is a conspicuous illustration of this important fact, for in certain groups it is very constant, or has some very evident significance, while in others it is so inconstant and diversified that it is of no use to the systematist. And this remarkable difference in the value of color may occur within the limits of a single genus. Only by extended knowledge of a group can it be determined what characters are of value for either the differentiation or the grouping of species. It is perfectly proper to speak of questioning the *validity* of a species and its validity must ultimately be determined by the constancy of the character or group of characters supposed to distinguish it. But it is not correct to speak of questioning the "validity" of a genus. Its desirability and the accuracy of its definition may either or both be questioned. One genus is as "valid" as another but the desirability of naming any group is a matter of opinion. And this brings us to the last of the principles I wish to formulate.

In all systematic work, the line between facts of nature and opinions of the worker should be sharply drawn; the value of the work often depends on the clearness of this line.

One of America's greatest zoologists was wont to repeat over and over again to his students these words: "The assertion that outstrips the evidence is a crime." Like most aphorisms of the kind this sentence needs some qualifications, but zoologists will hardly question the modified form that "the assertion as a fact, of what is really only an opinion, is a crime." The more unqualified the assertion, or the hazier the opinion, the greater is the crime. The opinions of a writer, particularly if based on careful observations and long experience, may be as valuable as his facts, but it ought never to be possible to confuse the two. It should be the aim of every systematic zoologist to set forth his facts so distinctly and so unmixed with opinions that any qualified worker may form accurate opinions for himself, and to so express his opinions that the justification for them in the facts of nature may be clear to all.

Having thus set forth what seem to me five of the most important principles of systematic zoology and realizing the possibility of varied shortcomings of my own with reference to them, I can only add in conclusion, as indicative of my repentance, *Peccavi.*

THE NARROWING CIRCLE OF THE ANIMAL KINGDOM

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IN the older regions of the country the scarcity of animals and birds has been noticed and studied for a long time, but many persons are unaware of the rapid decrease in bird and animal life in recent years. From the timbered regions of the far west, that region which was thought to contain inexhaustible supplies of game of all description, we are constantly hearing such queries as; "What has become of our Rocky Mountain goats and sheep, which were once so conspicuous on the cliffs of the Rockies? Where are the elk and other deer?" In Maine the same questions are being asked concerning the moose and caribou; while the whole country is wondering why the birds are disappearing so rapidly.

The question has aroused the government, as well as the naturalists, with the result that numerous investigations and reports have been made. Any one who has taken the trouble to do a little investigating along this line, if he has done no more than to investigate local conditions, has had no difficulty in arriving at the conclusion that many of our wild animals and birds are decreasing in numbers at an astonishingly great rate and that several forms have been practically wiped out of existence.

I do not think that any one section of the country can be accused of more wanton killing than another, for the people of all sections are guilty of carelessness in the matter of game preservation. Every one is familiar with the fact that millions of bison were killed on the plains of the West, but few are cognizant of the fact that the inhabitants of the Southeast had a hand in dealing, what came very near being the death blow to the buffalo tribe. From Carolina on the east to the foothills of the Rockies, the bison was wont to roam; very probably then, the inhabitants of the southeastern country had a hand in the slaughtering. Their herds were estimated to have contained from one hundred and fifty million to four hundred and fifty million. A government census, taken with as much care as was possible, showed that in 1850 the herds numbered about forty million head. By 1883 about the only traces of wild buffaloes in this country were the vast acres of prairies strewn with bones and horn. If the government had employed men to exterminate the bison, they could not have gone at it more thoroughly than the buffalo hunters and Indians did. From 1850 to 1883, a period of

thirty-three years, the number slain was more than two hundred and fifty million, or about eight million each year; a record which has few parallels. Ten or twelve years ago there were very few American children who had ever seen a bison. Just a few years ago, we all began to realize that if a single bison was to be left, effective means must be started to put a stop to the indiscriminate slaughter. The few remaining bison, under care and protection have thrived remarkably well, and increased their numbers considerably. The American Bison Society has recently taken the census of the bison, and reports that all told, there are twenty one hundred and eight of them distributed among three government herds, besides various private ones.

On account of the fact that the alligator is a native of the extreme southern part of this country, many people are uninformed as to the rapid decrease which the demand for 'gator skins has made upon the numbers of alligators in Florida and other southern states. Twenty years ago it was a common occurrence to find alligators of great size in many of the streams of North Carolina, South Carolina, Georgia, Mississippi, Florida and Louisiana. In all of these states excepting Florida and Louisiana, the saurian representatives are comparatively scarce. Florida has the greatest number now, not because of any legislation or special effort for their protection, but because the everglades and the mild climate constitute the natural habitat of the alligator. To-day Florida has laws for the protection of the alligator, and is making every effort to have them enforced. They were being killed in such great numbers that, with a few more years of the "pot hunter" and skin collector, the alligator would have been listed among "those which had been." A few figures will suffice to show to what extent the killing of alligators has gone. Between 1880 and 1890, three million eight hundred thousand alligators were killed in Florida alone; and during the year 1908 twenty thousand were killed. In the majority of cases the skin was taken off, and the rest of the body wasted. It was not until 1885 that the demand for the skins was so great, when suddenly fashion decreed that, satchels, pocket books, music rolls, etc., made of alligator skins were just the style; and the above figures show how it affected the number of alligators.

From reports, which represent practically the entire area of the United States, gathered by Dr. Hornaday, of the New York Zoological Garden, one can state without any fear of contradiction that the following mammals, in the wild state, are practically extinct or are rapidly becoming so. Among the ruminants or cud-chewing animals, the bison of course holds first place, with the wapiti or American elk (*Cervus canadensis*), moose (*Alces americana*) and woodland caribou (*Rangifer caribou*) good seconds. Notable among the smaller ruminants are: the Virginia or white tailed deer (*Cariacus virginianus*), mule deer (*Cari-*

acus macrotis), black-tailed deer (*Cariacus columbianus*), prong-horned antelope (*Antilocarpa americana*), Montana goat (*Ovis montana*) and the mountain goat (*Hoploceras montana*). Bears in general are greatly on the decrease, and especially the black bear (*Ursus americanus*) and the California grizzly bear (*Ursus horribilis horriæus*). The carnivores are represented by the puma or mountain lion (*Felis concolor*), jaguar (*Felis onca*), red lynx (*Lynx rufus*), otter (*Lutra canadensis*). The rodents, or gnawing animals, on the whole seem to be on the increase, but the most valuable member of the order to man, the beaver, (*Castor canadensis*) is fast nearing extinction.

Concerning the bears Morse's "Universal Geography" for 1812, states that eight hundred thousand hides were shipped out of the United States every year. If there is such a thing as a bear industry in this country now it is of exceedingly small importance. In 1784, from one city alone, Charleston, S. C., six hundred thousand deer hides were shipped; in 1812 the price paid for a buck was forty cents; in 1878 venison cost three and one fourth cents per pound; in 1908 it took forty cents to buy a pound of venison, just exactly what a whole buck cost in 1812. Evidently there are not as many deer as there used to be.

It is natural, of course, that the wild animals of a country should decrease as the population increases, since an increase in population means that new land must be cleared, and the wild animals living in the region of increase, killed off. In many countries, where the population per square mile is so much greater than it is here, there would be some excuse; but not in America where miles of prairie and mountain are uninhabited. There is not a single region in this country where the majority of species of mammals is not on the decrease.

Bird life, on the whole, has decreased a great deal more than animal life; there are a few regions, though, where birds are increasing in numbers. According to reports received from thirty-six states and territories, Dr. Hornaday is of the opinion that in the last fifteen or twenty years the bird life in the United States has been decreased by 46 per cent. The greatest amount of damage seems to have been done in Florida, where the decrease is 77 per cent. In Indian Territory, the region constituting the eastern portion of what is now the state of Oklahoma, the loss is 75 per cent. From Connecticut a loss of 75 per cent. is also reported. The states having the smallest losses are: Nebraska 10 per cent., Michigan 23 per cent., Colorado 28 per cent. and Massachusetts 27 per cent. In three states, North Carolina, California and Oregon, the balance of bird life has been maintained; that is, the losses in one form of bird life have been made up by increases in other forms. In North Carolina, along the coast region, bird life has suffered great losses, but in the thickly wooded mountainous regions of the western part of the state the birds have greatly increased in

numbers. In four states, and to them commendation is due, the number of birds has increased. They are Kansas, Wyoming, Washington and Utah.

What has become of the passenger pigeon (*Ectopistes migratorius*), prairie chicken (*Tympanucus cupido*), the Carolina paroquet (*Conurus carolinensis*); and why are the following so nearly extinct: blue bird (*Sialia sialis*), the white heron (*Ardea candidissima*)? In every case the answer is one or all of the following conditions: indiscriminate hunting, wanton slaughter, and the collection of plumes or of eggs. None of these are natural conditions, and therefore it is not beyond the power of man to better them.

The birds which are affected most by the indiscriminate hunting are the gallinaceous birds, such as the grouse, quail, partridge and turkeys. The wild ducks and shore birds are also considerably affected. The wading birds, among which are the various forms of heron and bittern, have found their worst enemies among the plume collectors, or plume thieves. The men who collect feathers from these birds are not content to pluck the feathers and release the birds, or to confine their depredations to the males; but they kill the female herons, for the plumes and egrets that they furnish, while they are on the nest. It is only during the mating season that the feathers are in a suitable condition for plucking, hence the annual raid made upon the nesting herons.

It seems strange that women, who by nature are supposed to possess so much gentleness and sympathy, and who shrink from anything that savors of cruelty, should be content to adorn their hats with feathers, the procuring of which necessitates so much wanton cruelty and murder. But Dame Fashion has decreed that feathers shall be worn; regardless of how they are secured, they have been worn, and a study of the following figures will give some idea of the effects thereby produced on the colonies of herons and egrets. Within the past twenty years the snowy heron has practically disappeared from China, where it was once so plentiful. Twenty years ago, there was in the region about Charleston, S. C., at least three million of these birds; to-day less than one hundred remain. There is but one small colony of the American egret left in this country, and that one is on the coast of South Carolina. This colony was fired into last year, and again this year, so that now less than twenty birds remain. It will be but a few years, unless some drastic measures are taken, before the history of this bird will be the same as that of the passenger pigeon. Our grandparents tell us of the times when the skies were darkened by the millions of pigeons which were seen in the middle west. Last year a reward of four hundred dollars was offered by a college professor to any one who could furnish accurate proof of a single nesting pair of passenger pigeons. I am of the opinion that no one applied for the reward.

In 1830 the Carolina paroquet was so numerous that it was reported that Audubon killed a half barrel with two shots of a shot gun. In Carolina not a single one remains, and in the wilds of Florida but few can be found.

The prairie chicken was once so abundant, that in Kentucky, where the slave owners fed it to the negroes, they tired of it and begged their masters not to make them eat it. It was commonly known as "nigger bird." To find the prairie chicken now, one must tramp the isolated regions of the west. Even in Indian Territory, a hunter is considered lucky if he even gets a shot at one. I have heard the old settlers say that the prairie chicken was once more abundant than the English sparrow is now.

The game birds are so nearly depleted, that our song birds are being killed off as a result. The quest for game birds having failed, and the desire to "kill something" being still unabated, the "hunter" "takes it out" on the song birds. The blue bird is fast nearing extinction, and the larks and several other songsters are suffering a considerable depletion in numbers.

After reading the above reports of killing and depletion, one is apt to take a pessimistic view of the situation; but thanks to the Audubon Societies, which are pretty well established in every state, the appointment of game wardens, who are beginning to realize that they are personally responsible for the condition of bird and animal life in their region, the issuing of hunting licenses, which necessarily prevents a great many unscrupulous men from hunting, and the widespread interest which is being manifested in the cause, there is no reason why the great decrease should continue.

FOOD PREPARATION AND ITS RELATION TO THE DEVELOPMENT OF EFFICIENT PERSONALITY IN THE HOME[1]

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Introduction

THE main purpose of this paper is to show something of the manner in which woman's work in the home in regulating and arranging the diet of her family may help or hinder their harmonious vital, mental, moral and social development as well as her own, through her ability or inability to make use of the accumulated knowledge of conditions necessary for human welfare.

The purpose also is to show if possible the importance of greater knowledge of what is best for individual welfare on the part of homemakers to whom is intrusted the first and early care of the potential citizen or the social personality with its varied phenomena of vitality, mentality, morality and sociality.

Vitality is fundamental. Without good health we can not expect the highest mental development. Without good health and the vital conditions which produce it we can not expect a high morality. Without good health and the sense of well being which accompanies it, we can not expect a deep sense of sociality or social sympathy.

Two factors operate to produce vitality, *i. e.*, heredity and hygiene. Within the limits of this paper heredity has no place. One phase alone of hygiene will be discussed. The hygienic methods of improving vitality may be classed in three groups—public hygiene or the activities of government, such as general sanitary measures; semi-public hygiene or the activities of the medical profession and institutions such as hospitals; and personal hygiene or the private life of the individual and family.

The subject of personal hygiene has three main divisions: nutrition or suitable foods; environment—air, soil, clothing, dwellings and so on, and activity or the proper balance between work, play and sleep. Still another element in personal hygiene concerns the sex relation. These divisions of the subject of personal hygiene are closely bound together in their importance to human welfare. Yet food is the primary essential of the human organism. Food, then, is the phase of

[1] The writer wishes to express her sense of obligation in the preparation of this paper to the department of sociology and economics and the department of chemistry of the State University of Iowa.

personal hygiene which will be considered in this paper. It will be discussed in its relation to the development of efficient social personality in the home.

We trace first the development of public sentiment in regard to the importance of food suitable to maintain the body in a state of efficiency and health.

Distinct progress in the study of the foods necessary for the body was made when chemists and physiologists began to work hand in hand in their investigations. Liebig (1803–1873) took a step in advance when he declared that protein foods are the source of energy and his statements held sway for many years until they were overthrown by experimental evidence. Fick, who in 1865, made an ascent of the Faulhorn on a diet entirely without protein did much to overthrow Liebig's theory.[2]

Other original investigations followed, for the necessity of experimental evidence had by that time been fully established, until we come to the name of Karl von Voit, who in his studies in metabolism, sought to learn the kinds and quantities of food used by people of different occupations.[3]

Professor Atwater, lately deceased, contributed much by original studies to the subject of diet and nutrition in our own country.[4] But the most scholarly and thorough investigations in this country on the subject of diet in its relation to the actual necessities of the body have been carried on by Dr. Chittenden, professor of physiological chemistry at Yale University and director of the Sheffield Scientific School.[5] In these he has sought to establish by a series of accurate tests of sufficient number to warrant conclusions the minimum requirements of food for the body under certain conditions. He sought to determine the real physiological needs of the body for food in order that energy may be furnished and tissue be built up and replaced.

These data furnished by the chemists and the physiologists concerning the food necessities for individual welfare, the sociologist makes use of in his study of society, for a society can be no more potent than is the personality of the individuals who compose it. Hence, as Professor Giddings says, "The supreme result of efficient social organization and the supreme test of efficiency is the development of the social man." [6]

[2] Gesammelte Schriften von Adolf Fick, "Ueber die Entstehung der Muskelkraft," Band 2.

[3] Von Voit, "Physiologie des Allgemeinen Stoffwechsels und der Ernaehrung."

[4] Atwater, "Foods, Nutritive Value and Cost," "Food and Diet," and others, U. S. Department of Agriculture..

[5] Chittenden, "Physiological Economy in Nutrition," 1904; Chittenden, "The Nutrition of Man," 1907. F. A. Stokes Co.

[6] Giddings, "Inductive Sociology," p. 248.

The phenomena of personality may be divided into four classes: those of vitality, mentality, morality and sociality. According to the author just quoted, "the development of the social personality is measured by the increase of vitality, of sound and high mentality, of morality and of sociality; and by a decrease in the population of the number of the defective, the abnormal, the immoral, and of the desocialized, the deindividualized and the degraded."[7]

The development of vitality is fundamental in harmonious personal growth. From the days of the early Greeks the necessity of a sound body as a pre-requisite of a sound mind has been fully recognized and sought for in accordance with the knowledge available for the subject. The recognition of the connection between moral life and mental life has been somewhat more tardy, as also has been the knowledge of the connection between morality and sociality. Even though Jesus centuries ago declared, "Thou shalt love thy neighbor as thyself," and "He that saveth his life shall lose it," we have been very slow to comprehend the fact that universal brotherhood is indicative of a high type of morality.

However, we have come now to see the fact that sociality rests upon morality, that morality is a differentiated form of mental life, and mental life is conditioned upon physical life while efficient physical life depends primarily upon the food we eat.

Consequently some of the essential studies of the sociologist are food necessities and vital statistics in order that he may understand the possibilities of harmonious development of the social man. This century has been especially rich in studies of this kind, but as long ago as the eighteenth century Adam Smith expounded the advantage to the community of a rising standard of living among laboring classes.[8] In our own century the work of investigation into the standards of living in their relation to social welfare have been undertaken by many individuals and agencies.[9]

The general plan of these investigations has been a study of living conditions as they actually exist among working people, for the most part, because the animating purpose of many of these inquiries has been the desire to improve the condition of the wage earner.

For instance, Mrs. More in the book entitled "Wage Earner's Budgets" gives the results of a personal investigation into the standards and cost of living of two hundred families in two districts in New

[7] *Ibid.*, p. 250.

[8] Adam Smith, "Wealth of Nations," part 1, chapter 8.

[9] The publications of the United States Bureau of Labor, the publications of the Bureaus of Labor of Connecticut and Massachusetts and the publications of the Department of Agriculture; Devine, "Principles of Relief," chapter 3; Bosanquet, "The Standard of Life and other Studies"; Booth, "Life and Labor of People in London"; More, "Wage Earner's Budgets"; Chapin, "The Standard of Living in New York City."

York City. The people represented the leading trades and occupations of city workmen under the usual city conditions. Her conclusion was that a well-nourished family of five needs at least $6 a week for food in households where there is good management, and she says further that what is done with the weekly income and the amount of comfort it will bring depends almost entirely upon the character and ability of the wife.

Professor Chapin in his book entitled "The Standard of Living in New York" presents the schedule of expenses of 391 families on an income ranging from $500 to $1,000 per year. The average expenditure for food was $400 a year per family, but in the families whose income fell below $800 or $900 he found them often under-fed because rent must consume so large a part of their income. Dr. F. P. Underhill in commenting upon the nutrition of people of these incomes says that results show that when less than 22 cents per man a day is spent for food the nourishment derived is insufficient. But he adds that it does not necessarily follow that in every family where 22 cents per man a day is spent the people are well nourished, for not all families spend their money wisely, *i. e.*, one report showing that out of $6.17 a week spent for food $1.83 was spent for beer, wine and pickles.

Dr. Irving Fisher, professor of political science at Yale University, has published the results of two series of investigations as to the effect of diet on endurance. He finds endurance much increased by thorough mastication of food, which unconsciously leads to a much lower protein intake than is usually considered necessary in the so-called dietary standards.[10]

These authorities are mentioned only to show something of the importance which the sociologist to-day is attaching to the phenomena of vitality in the development of efficient social personality.

For the harmonious development of efficient social personality certain general conditions of well-being are essential in which all the members of the community share or may share and, even though these are external to the individuality, they are still necessary to its perfection and happiness. "These external conditions include the security of life and possessions which is maintained by the political system; the liberty and justice which are maintained by the legal system; the material well-being which is created by the economic system; the knowledge and the command over nature which are created by the cultural system. These proximate ends collectively we may call public utilities." [11]

These public utilities are means to an ultimate end. They are of

[10] Fisher, "Influence of Flesh Eating on Endurance," *Yale Medical Journal*, March, 1907; Fisher, "The Effects of Diet on Endurance," *The Transactions of the Connecticut Academy of Arts and Sciences.*

[11] Giddings, "Inductive Sociology," part 4, The Social Welfare.

value only as they serve the individual life, the higher life of moral and intellectual development. By their means is developed a social personality, and this social personality—so far the highest product of evolution—the moral, intellectual and social man is the ultimate end of the social organization.

These proximate ends or public utilities take the form of various organizations in the political, the legal, the economic and cultural systems.

The supreme test of the efficiency of any social organization is the development of the personality of the social man. If the man himself becomes less social, less rational, less manly; if he falls from the highest type which seeks self-realization through a critical intelligence and emotional self-control to one of these lower types that manifest only the primitive virtues of power; if he becomes unsocial—the social organization whatever its apparent merits, is failing to achieve its supreme object. If, on the contrary, man is becoming ever better as a human being, more rational, more sympathetic, with an ever-broadening consciousness of kind—then whatever its apparent defects, the social organization is sound and efficient.[12]

The home is one of these utilities for the development of the social man. The purpose of the home as a social organization is two-fold—economic and cultural. It is a purposive organization existing for convenience in the consumption of wealth as well as for the cultural purposes of parents and children.

Since the development of social personality through its organizations is the ultimate end of society, the cultural side of the home should perhaps be more emphasized than it is, but as our economic system is organized to-day the economic side of home life receives undue emphasis, owing to the social waste of labor which occurs because each housewife does her own housework, the food preparation, the sewing, the laundry work for her own little group, when by combination there could be a great saving in time and strength and more leisure for real cultural advancement. Society is coming slowly to understand something of this social waste of labor and gradually there have been developing industries which relieve the homes of much sewing, laundry work, and even food preparation.

The home is a human institution, and as such is capable of change and improvement. Other human institutions have come and gone, but the home of to-day in many particulars remains essentially the same as it was when our cave-dwelling ancestors left the woman at home to guard the fire, care for the children and, incidentally, to prepare the food, while they roamed abroad in search of game and new experiences. Those who insist that a woman's place is at home by divine decree need only to study the life of primitive man to find out how very human are some of our domestic customs, for they will then see this distinction, that while nature has specialized woman for child-bearing, it is society

[12] Giddings, "Inductive Sociology," p. 249.

which has specialized her for housework. To be sure, a custom which has continued as long as this one of woman remaining by the fireside must have as its foundation something which is fundamentally right for social development. Yet so many myths have grown up about this custom that we are in danger at times of mistaking these additions for the good of the original idea. Because of these erroneous ideas current, popular opinion is inclined immediately to conclude, if for economic reasons a woman strays from the fireside, that she and her husband are incompatible, or that he is unwilling to support her and that in some way she is neglecting what is popularly supposed to be her divinely appointed mission. Of course such a conclusion is often unjust and not warranted by the facts.

In discussing the subject of the preparation of food, we accept conditions as they are; that woman is specialized by society as the housekeeper and food purveyor to the various groups called families.

In spite of the fact that many of the home industries have developed into world-wide industries there still remains for the housemother much of the food preparation for her family. The necessary meals for one's family are the essential fact which confront each housewife anew each day. No matter what other home activity can be neglected, that one duty of preparing food can not be omitted. How often we hear women make some such remark as this, "I was too sick to do anything else but get barely enough for the family to eat." This shows that every other home duty can in extremity be left undone except that one. Food preparation then is the fundamental duty of the housewife to-day. "A good stomach kept in a healthy condition is the foundation of all true greatness," says Dr. Tyler, professor of biology at Amherst College.

The housemother's first duty then after bearing her family is to provide them with food for their growing needs which shall give them the best endurance for life's conflict. But her responsibility is much greater than this, for closely connected with the necessity for food are the other hygienic necessities for survival—air, water, sunshine, shelter, rest, all in due season; and depending upon these vital necessities are the opportunities for the development of the mental, moral and social personality or the completely social man. Because woman is specialized for home work, these wider responsibilities for individual growth have, in a large measure, become hers also.

The home as a social organization stands as an agent of help or hindrance midway between the well-established theories of the scientists concerning human welfare, on the one hand, and society, on the other, where the finished product of personality asserts itself as a social force. What that force shall be the home can alone determine for by its agency, the theories concerning human welfare must be put into practise and through it as a clearing house must pass in their operation

many of the most potent influences which fashion the character of the social personality or the social man.

Naturally then the sociologist in considering the factors which determine social welfare must give especial attention to the home and many phases of its life.

For instance, if the physiological chemists prove that the individual requires for full vital development food of certain quality and quantity to produce from 2,500 to 3,000 calories of energy per day and that individual in his home through the ignorance on the part of those who prepare and serve the food consumes a greater or less amount of innutritious food, just to that degree is the home responsible for the weakening of the vital power of the social personality and since vitality is fundamental, the mentality, the morality and sociality of the individual will in time also suffer.

As custom is at present, we all concede that the home is the center of food supply to the individual and woman's main work in the home for which to-day she is specialized by society is the serving of food to her family which in the majority of instances she has herself prepared, for we are told that only ten per cent. of the women in the country have the luxury of a cook ether than themselves. If in fulfilling this humanly appointed mission of food center, any individual or group of individuals in the home in carrying out this plan lose from overwork or under education an opportunity for the harmonious development of the four divisions of social personality—the vital, the mental, the moral and the social, the home standing as it does midway between the knowledge of what is best for human nature in its development and the finished product or the social individual in society—is a hindrance to human progress.

Applying the sociological tests of personality to home life we have a right to ask if our homes, as at present conducted, are making mankind better as human beings, more rational, more sympathetic, with an everbroadening consciousness of kind, and whether there is a decrease in the number of the defective, the abnormal, the unmoral and desocialized. We have a right to go a step further and ask if in the development of this social personality there comes to the individual the satisfaction of its own activity and growth or what Giddings calls "cumulative happiness." That is, in the performance of this specialized industry as homemaker is woman enjoying a sense of satisfaction in her own growth and activity and is she happy in her work? Neither men nor women can have a sense of satisfaction or cumulative happiness in their tasks unless they are fitted for them and do not overwork at them.

We are here according to the modern interpretation of the teachings of Jesus to perform our best service to society and we can do this only by the best individual growth and expression. The right kind of

a home can do much to further these results. Warden J. C. Sanders, of the State Penitentiary at Fort Madison, Iowa, said that out of the 455 inmates, very few had had the advantage of a good home.[13]

Although woman is specialized for this important business of home work upon the outcome of which depends first the vital, then the mental, moral and social, welfare of mankind, she receives in but few cases any preparation for her important task. She takes the methods of housework which are traditional in her environment and makes use of them according to her individual training and aptitude. The exceptional woman may use all the data of the scientists in the administration of her home. What she is able to do ought not to be made the measure of what the average woman may be expected to do. The average woman goes blindly on in her specialized work, laboring hard at a task for which she has no aid but home traditions and the columns of the home magazines.

To be sure the home magazines are contributing much toward better conditions of home living, for many women would not know that scientists are at work continually on problems of home betterment were not some of the results of their investigations made available through the medium of the home magazines.

The bulletins of the Department of Agriculture, the farmer's institutes throughout the country, the home economics movement,[14] and many writers—Mrs. Richards, Miss Barrows, Miss Bevier, Mrs. Rorer, Miss Kinne, Mrs. Hill, Miss Farmer, Miss Hunt, Mrs. Lincoln and others—are doing much by a crusade of enlightenment to improve conditions of foods, their preparation and uses in our homes. That is, they are trying to make available for women the knowledge of the scientists, which either is not available for the average woman or else is beyond her mental reach.

For instance, two noteworthy books on the subject of nutrition by Professor Chittenden, of Yale University, have been published in recent years.[15] They are noteworthy because by scientific tests upon different classes of people they show the exact needs of the body for protein, the material for building up and replacing tissue. Consequently some very definite conclusions can be drawn concerning food customs which should be known to every woman and prevail in every household. The essential parts of the books are so plainly and entertainingly written that a woman with at least a high school education could understand them and profit by them. Yet inquiry reveals very few housekeepers who have read them. The reason for this ignorance can be attributed to the fact that as yet woman in her evolution has not reached

[13] An address delivered before the Iowa City High School, December, 1909.

[14] Bevier and Usher, "History of the Household Economics Movement."

[15] Chittenden, "Physiological Economy of Nutrition," Chittenden, "The Nutrition of Man." The F. A. Stokes Company.

the state of mind when she expects to enjoy or understand anything scientific, so she does not seek out that class of reading. Meanwhile, nevertheless, she is in charge of the vital development of the race. A strange inconsistency! Thus we see that in most cases she is not fitted for her work and hence can have no sense of satisfaction in it.

As previously stated the purpose of this paper is to show the connection between woman's work in the home in preparing and serving food for her family and the harmonious development of personality; and also to indicate that as conditions now prevail in society she is unable to make use of the accumulated knowledge of scientists as to what is best for human welfare.

With this purpose before us we need to keep in mind the image of the home as an intermediate agent between the scientific knowledge of what is best for human development, on the one hand, and on the other the finished product of personality as we find it in society. Since the home stands as the connecting link between these two—the knowledge and the result, it must of necessity help or hinder the harmonious development of the social personality or the individual in his relations to his fellow men. Hence anything which will improve home conditions is of great importance to society in its attempts at individual and general progress.

In the face of these responsibilities which center around the home and the housemother in the vital, mental, moral and social care of her family, because she is specialized by society for home work, let us consider some of the results in the working out of this system.

Statistics tell us that under the present home system one fourth of all deaths for the United States during the year 1908 were of children under five years of age.[16] The infant mortality of England was higher for the three years 1896–1900 than for 1861–65.[17] Of the total deaths in Iowa in August, 1910, about one fifth were under one year of age and of these over 80 per cent. were from cholera infantum, a disease largely preventable through hygienic measures.[18]

It is stated of all diseases of infancy between the ages of 2 and 6 sixty-seven per cent. may be prevented on the basis of our present knowledge of sanitary measures, were they widely used.[19]

Statistics tell us that under the present home system, the prevalence of disease greatly impairs efficiency.

In the United States, 500,000 people are constantly ill from tuberculosis alone, which is in a large measure a preventable disease in

[16] "Mortality Statistics," 1908, p. 8, Special Census Report, Department of Commerce and Labor.

[17] *Ibid.*, p. 9.

[18] Rockwood, POPULAR SCIENCE MONTHLY, March, 1911.

[19] Irving Fisher, "Bulletin of the Committee of One Hundred on National Health."

the homes where it is understood and the necessary diet and food are provided.[20]

The minor ailments, such as colds and sore throats, cause even well men to lose at least five days a year from their work.[21] Yet investigation and research are showing that these minor ailments can be controlled in a large measure by diet.[22] Professor Fisher says that he knows scores of cases in which the tendency to take cold has been almost completely overcome by diet. Such being the case it will be necessary for those who prepare and serve the food to be cognizant of what kind of food the body requires for its highest efficiency, and since as society is now organized, the preparation of food is woman's work, it must be possible for women to know in some way the latest results of scientific research in foods and general hygiene in order to prevent disease.

Statistics tell us that misery, which represents maladjustment to environment, is frequent in rural as well as in city life. "Perfect health, full physical vigor and overflowing animal spirits are much more rare among dependent classes than moral virtues. The prevalence of ill health is due in large part of course to ignorance and the continued neglect of the elementary rules of personal hygiene." [23]

It is a noteworthy fact that after the destruction of the homes by the San Francisco earthquake the health of the community as a whole improved, due no doubt to the plain, substantial food, the outdoor life and the military system of sanitation, where before people had been living in homes in accordance with their individual ignorance. Professor Devine states also that there is great need of medical knowledge in our homes to overcome the ravages of such diseases as the minor maladies of rheumatism and colds.[24] This puts the responsibility of human health on the home and the woman in the home who has charge of the preparation of food, the vital welfare of mankind and hence the other dependent phenomena of personality.

Professor Devine says, in speaking of the waste of infant life, that in England 10 per cent. of the babies of aristocratic families die in the first year, 21 per cent. of the middle class, and 32 per cent. of the laboring class, which facts show that the ignorance of the proper care of infant life is not altogether due to poverty.[25]

Many charity workers report that the "unpreparedness of the wife and mother" to make a home is often a cause of misery, because through ignorance disease comes and disability, with much resultant suffering and want. In these homes where the unprepared mothers try often-

[20] *Ibid.*, p. 3.
[21] *Ibid.*, p. 39.
[22] *Ibid.*, p. 40.
[23] Devine, "Misery and its Causes," p. 74.
[24] *Ibid.*, p. 84.
[25] *Survey*, December 4, 1909.

times so nobly to adjust the personalities of themselves and their families to adverse conditions, Professor Devine says, "We find the beginnings of those tendencies which often lead to suicide or crime, to disabling disease or helpfulness." In this same connection of the preparation of home makers for adapting themselves and their families to their environment, charity workers agree that among working people the women who have been in domestic service are much better able to manage on their income than those who have spent their girlhood in factories.[26] Intemperance, which is known by all charity workers to be a prolific cause of crime, is often excused in its first manifestations as resulting from innutritious food. In families where the wages would be sufficient to supply nutritious food, the homemakers do not know how to buy or to prepare it. Hence previous domestic training is of great value.

This "unpreparedness" of women in our homes is not confined alone to a knowledge of foods. Because woman is specialized by society for housework, and the care of children, the general responsibility for the health of her family is hers also. But so often through ignorance she is not equal to this responsibility. For instance, statistics and the reports of the various state charitable institutions show that a large per cent. of blindness among children is due to diseased conditions which might be remedied by intelligent care at birth,[27] or might have been prevented years before by a proper knowledge of sex hygiene.

Intermarrying is also given by experts as a cause of physical degeneracy such as deaf mutism. Both of these social errors might be diminished by greater knowledge on the part of the guardians of the homes of the vital necessities of the race in the matter of sex and reproduction. The economic necessity which presses so hard to-day upon the man as bread-winner of the family lays all the more responsibility upon the woman in the home not only as in the first essential of food, but in all hygienic matters which pertain to vital efficiency.

Statistics tell us that with the present home system divorce is increasing much faster than the population. Divorce was about three times greater in 1905 than in 1870.[28]

The special census report of the Department of Commerce and Labor shows that the most important ground for divorce is desertion and of the divorces granted to the husband nearly one half had desertions as their cause. That is, one half of the husbands who sued for divorce had for a cause the desertion of the wives. It would look from this fact as though women are growing weary of home conditions.

We have then the fact that with our present system of homes, one

[26] More, "Wage Earner's Budgets."

[27] See report for 1908 Illinois Institution for the Blind.

[28] "Marriage and Divorce," p. 11, Special Census Report, Department of Commerce and Labor.

fourth of all deaths are of children under five—those who are entirely dependent on the home whose diseases in 67 per cent. of the cases could be prevented by proper diet and care. We have the fact that 500,000 people in the United States are ill of tuberculosis and that such prevalent diseases can, in many cases, be cured by diet and fresh air. We have the fact that as estimated even well people lose at least five days a year from colds and minor ailments which might have been largely prevented by a proper diet. We have the fact that one half of the women who are divorced by their husbands desert home voluntarily. We have the fact that many charity workers give as their testimony that much social misery is caused by the "unpreparedness" of the homemakers. We have statistics to show the great waste of infant life in mansion as well as in humbler home. We have the statement of Professor Devine, the well-known charity expert, that in many homes we find the beginnings of tendencies which often lead to crime and disabling disease. We have the statements that innutritious food is a prolific cause of intemperance, which of itself leads to crime. We have the facts that much blindness and physical degeneracy might be prevented by a proper knowledge made available to the masses through the housemother in the home.

In the face of all these facts it would certainly appear that woman, who is the guardian of the home, is either ignorant of the proper consumption of wealth in the home in serving human welfare or else she is remiss in her duty. It is safe to say that not all women would be consciously negligent or remiss in their life's work, so the natural conclusion is that woman for the most part is ignorant of many of the essentials of the great mission assigned her. This ignorance is not strange, since in our educational system she receives slight preparation for this her real life's work. As has been said before, all the aid she has are home traditions and the home magazine, and in the majority of instances she is ignorant of the noteworthy investigations along her own line of work.

Ignorance of right living being so apparent in the face of these statistics, it has thus been shown how woman's specialized work in the home in charge of the food supply can hinder the harmonious development of efficient personality through her inability primarily to maintain and increase the vitality of those intrusted to her.

On the other hand, in order to fulfill the further purpose of this paper and to show something of the manner in which woman's work in the home in providing food for her family may help their harmonious mental, moral and social development, and to show if possible the importance of greater knowledge of what is best for individual welfare on the part of the homemakers, three divisions of the subject are made.

1. Since by results woman is shown so ignorant of proper methods of nutrition which will prevent disease and death, methods of improv-

ing the commissary departments of our homes are suggested by means of education.

2. Suggestions are made of a practical and natural method of developing the efficient social personality of the child in the home, and an attempt is made to show how a woman following out the industry for which mankind has specialized her can develop her own social personality.

3. At least one preventative of divorce and unhappy home life is suggested.

1. The Need of Educated Homemakers

Let us bear in mind the fact stated before that the home and its caretakers stand as a connecting link between the knowledge of what is best for the individual and the finished product of personality as we find it in society. Or, in other words, the function of the home and of those who minister there is the adjustment of the individual to society through the utilities of the home which are both economic and cultural. Certainly such important work should require some special training. While primarily woman's work is that of dietitian in the home, she must not specialize in this capacity at the sacrifice of her effectiveness as a teacher or the cultural size of home life will suffer. Neither must her training as a dietician and a teacher exclude the training necessary as a financier and as an employer of labor in a broad sense, for the home is in direct touch with the labor problem on all sides. The liveliest imagination and inventive genius she will need also to develop to enable her to meet with discrimination and equanimity the daily complex problems of home life.

It is to be hoped that as yet woman's education is in a transitional stage. The last half century has been given up to proving that women can learn the same lessons as men if they wish to do so. It is very desirable that the next half century may mark a much greater triumph in woman's education by making plain and popular the fact that although she can learn the same lessons as a man she, as a woman, has more important ones to learn of an entirely different nature, bearing on her profession of home making.

No man without special training is likely to be employed as consulting engineer on so important an enterprise as the Panama Canal, yet women the country over are intrusted with the vital, the mental, the moral and social welfare of the individuals who make up the state, without any preparation whatever beyond an inheritance of tradition and such additional information as can be gained from home magazines or such other literature as their minds are able to grasp.

There is a sentiment current in respect to woman's higher education that if she is given culture studies, ability will in some way come to her for her life's work. Culture studies are good, but they are only part of the preparation needed by her. She needs for her life's work

much more preparation than is ordinarily included under the subject of domestic science in order that she may be competent to develop the personalities of her family in every way. A suitable course for her in order to be of wide value should be a bringing together of all the work of her college days in its bearing upon individual adjustment to society through the medium of the home. The studies of literature, art, music, psychology, pedagogy, child study, emergency nursing, chemistry, physiology, biology, bacteriology, botany, sociology, *in their bearing upon home life,* will all be necessary for this ideally equipped homemaker. She needs, in other words, to be taught how to control her environment by making use of the knowledge which is available for race progress.

It is not going too far for the state through its educational institutions to require that each woman graduate who goes out from their walls shall be thus equipped for the work which is of greatest value to the state through the home. For instance, the state of Iowa now requires a course in pedagogy extending through much of two years for those who wish to have a state certificate to teach. Iowa might well go much farther and require that each woman who graduates from her university shall be prepared by suitable studies for the position of homemaker which sooner or later she may assume. Iowa is a progressive state in many respects. She is the first to put her educational institutions under a coordinating board. This board has within its power to take a distinct step in advance by enabling the university to offer studies which are especially suited for developing educated women as homemakers and as guardians of efficient social personality.

Most state agricultural colleges and state normal colleges have schools of domestic science to train teachers. The state universities as the crown of the educational system need training schools for wives and mothers, with all the advantages which higher education can give. This training must be of the very highest grade and no expense should be spared to make and keep it thus, so that every woman who goes forth from their halls shall be a center of light in the broadest way on the subjects of the hygiene of environment, of nutrition and of activity. If these conditions can be made to prevail in all our educational institutions, it is safe to say that the coming century will mark great vital, mental, moral and social advancement of the human race. Statistics tell us that at the present time 74,908[29] women are enrolled in the higher institutions of learning in this country. If each of these 75,000 college women and all who succeed them could go forth from their college life thoroughly prepared for their duties as women a great increase in individual and national efficiency might be expected.

The fact that many women say they "hate house work" does not lessen their responsibility for doing it well since they undertake to do it.

[29] Wm. G. Curtis, "Ages of Universities," *Record Herald,* April 15, 1910.

A proper education in the fundamentals, the purposes, the methods and the results of home work would no doubt go far to lessen the dislike for that form of labor. The difficulty with the "Man With a Hoe" and the woman with a broom is often the mere fact that they see no connection between present effort and remote results, and thus have no sense of satisfaction or happiness in their work.

Until by a process of evolution some plan of farther combination or socialization of home industries is worked out, in order to raise the standard of home industries it is necessary to take immediate steps to improve conditions in our homes. A wholesale campaign of education of our girls, beginning with the grade schools and extending through our colleges, is the most hopeful means available for improving our homes in their work of developing and maintaining individual and social welfare through the proper adjustment of the individual to society.

2. Home Methods of Developing Personality

One of the difficulties of our educational system to-day is that educated women seem to feel that when they assume the responsibilities of home work they have been made to surrender to disuse whatever mentality they possess. Indeed, one very capable woman said to the writer soon after her marriage, when she was wrestling with the difficulties of domestic management, "Do you not feel your mind becoming atrophied with all this petty round of duties?" In order to be loyal to our little home nest, I replied, "No indeed, I find that my domestic science takes as much mentality as my political science did." I have been trying ever since to live up to that remark, and I have found that the homemaker by following out her path of duty can have an opportunity for mental, moral and social development in proportion to her desire for growth.

The whole world of science centers around the daily work of preparing food. The housewife who wishes mental expansion in this line can begin by perusing the numerous food bulletins of the Department of Agriculture which are provided free. She can hang her kitchen walls with the food charts furnished by the Department of Agriculture for a consideration and learn while at her work the relative values of foods. This knowledge will prepare her to be interested in the many food experiments of the large experiment stations, and while following them through the publications she can add to them by carefully kept records of similar experiments in her own home, and if she is of a literary turn of mind she will find a ready sale for such articles as she chooses to write on the subject. Personal experience has verified this in the study of the food requirements of growing children.[30]

Her interest in her own growing family can lead her to a study of the development of the family, primitive culture and the development

[30] E. W. and L. C. Rockwood, *Science*, XXXII., p. 351.

of the home and the different phases of what Baldwin calls "the dialectic of personal growth" which occurs in the socialization of each of her children. While she is increasing her own stock of information in this way she will find that she is becoming a much more interesting companion for her children and is able to show them their real place and share in the world's work. In this way she can exert a much wider influence over them than by merely providing for their physical wants.

We are accustomed to say that the human necessities are food, clothing and shelter. We might better say that the human necessities are food, clothing, shelter and thoughts, for the mind needs food as well as the body. A growing child can get along without clothes and shelter if the climate is not too severe, but he must have physical food and mental food or else fail in human evolution. The mother makes a dire mistake if she ministers to the physical needs alone, and neglects the mental, moral and social personality of her child. While walking along the path of her own home industry, she will find that she can interest her children in world-wide problems, for children can become interested in almost any subject.

For instance, the boys I know best became very much interested in primitive culture, primitive man and his investigations growing out of their interest in the domestic use of fire. They read with delight "The Story of Ab" and parts of Jack London's "Before Adam." They constantly asked for anything new on these subjects. One day their mother heard some one say that when a man is drowned he is always found with his arms up over his head and that this posture is probably a survival of his tree-dwelling days. A few days afterward, the twelve-year-old boy came into the house much the worse for wear, muddy, torn and bruised, but with face radiant. To his mother's query concerning the cause of his condition he exclaimed, "I fell through a manger in an old barn, I suppose I am hurt. I don't know. I didn't have time to think, for when I came down I found my arms were up over my head and I am sure my ancestors must have been tree men."

That mother by following along the path of her own duty had succeeded unconsciously in teaching her boy the power of mind over matter or the uplifting power of an idea and of awakening in him an interest in historical and sociological study.

Lessons in wider social service and morality can be taught just from the necessity of the housemother's preparing food, for children can early be taught to share good things with others less fortunate and they can cultivate the spirit of hospitality.

However, it is quite difficult much of the time for the mother in the home to cultivate a wide feeling of brotherhood in her children, just because the mad scramble toward self preservation which the household

duties of to-day entail upon her, if she has no outside help, is apt to develop in the whole family an unwholesome egoism.

A small minority of the women of the country have house servants. This fact means then that the majority of the women, if they do their housework well in all its departments, must have a proper idea of values in order to enable them to do the essentials and leave the non-essentials. However, in order to be an ideal housewife and mother in her work of developing the personality of her family, each woman will need all the aid which education and training can give her as well as a still farther combination of some home industries in order to enable her to have time for the real essentials of abundant life.

Enough has been said to indicate how a woman in following out the profession for which mankind has specialized her in the home can develop her personality in its various lines and that of her children at the same time, if she has wisdom and training. Upon what high ideals she is weaving into their lives depends the steady advancement of the human race.

The supreme moments of the homemaker's life are those when she realizes that her family turn to her for counsel in the deeper questions of life as well as for the fundamental physical needs of food, clothing and shelter.

Not long ago several hundred club women in one of the eastern states were asked to reply to this question, "Who is the greatest woman in history?" Numerous replies were received and a great many women known to history were named. The prize was given to this answer: "The wife of a man of moderate means who does her own cooking, washing and ironing, brings up a large family of boys and girls to be useful members of society, and finds time for her own intellectual and moral improvement—she is the greatest woman in history."

Alarmists tell us sometimes that the home is disintegrating, that with the invasion of some women into industry and the indifference of others in regard to their home responsibilities, the death knell of the home is sounded. However, as long as the home can contribute anything to the development of personality and race progress, it will remain. With advancing education and civilization, no doubt, several of the functions which we now consider necessary will pass from the home, but our homes as the sanctuary of family life are not in danger of disintegration. While there are father-love and mother-love and dependent childhood there will be homes where the physical, the mental, the moral and the social personality can be developed.

If any one thinks the home can go and institutions can take the place of home life with its many activities in the development of personality, let him read this statement, which is typical of many other authorities on the subject from Mr. R. R. Reeder, for many years superintendent of the New York Orphan Asylum.

The most important part of the social and moral education of a child normally situated is the conversation especially the table talk with the parents. It is here the children get their views of life before starting out into the larger world they must enter—I must add also just here that the most valuable part of the child's industrial training is his cooperation with parents either by labor or by economic use of their means in maintaining and promoting the interests of the home.[31]

As long, then, as there is a demand for the influences of home life, the home in some form will continue, for we have not yet outlived the beneficent influences of home life, even though we have outlived some of its former customs.

3. A Prevention for Divorce

The subject of divorce is one which much concerns the sociologists and theologians to-day because of its demoralizing influence on the development of efficient personality in the family.

Satistics tell us that during the period from 1900–1905, while the population increased 8.7 per cent., divorces increased 22.1 per cent.[32]

It is not the purpose of this paper to enter upon a discussion of divorce except in so far as it is affected by woman's specialized industry in the home of food preparation and resulting necessities. Statistics are wanting on the subject, because as yet the sociologist has not known how to collect them, but a careful observation extending over fifteen years has led to the conclusion that many of our archaic home conditions are prolific causes of discontent and incompatibility. For one thing a woman who must work sixteen hours a day at unspecialized industry with the attendant fatigue, is unable to compete in charm oftentimes with the leisure parasitic class whose lives are devoted to pleasing men. Such overworked women are too tired to be interested in men's affairs or themselves interesting. Oftentimes because of this lack of leisure the discordant note is struck which later grows into utter lack of harmony.

Sometimes too the duties of married life are so taxing in the early years when the children are small that women, because of their excess of physical work, begin to feel a mental deterioration, and this consciousness of a lack of growth or of cumulative happiness often is the pathway leading to the divorce court. On the other hand, if a woman by means of any previous training is enabled to keep in touch with the mental life of her family as well as the physical life, she has in her work of motherhood found the one thing in life worth while, and in her work then she can feel a sense of satisfaction in her own growth and activity or "cumulative happiness," for she has found her share of the world's work. All the learning she can acquire will be none too

[31] "Charities," Vol. 11, 1908, p. 151.

[32] "Marriage and Divorce," Special Census Report, Department of Commerce and Labor, 1909.

great for her task, for the growing child is a many-sided personality interested in many things and the mother being most closely associated with him is naturally his teacher and guide, and must know something of many things in order to come into sympathetic touch with his busy brain.

We know, however, that divorce frequently comes in families where women are really idlers in the economic field, who have no responsibility beyond a good time and to be supported by their husbands. In these cases idleness, discontent, desertion and divorce are the result. A socialization of industry would be a good thing for this type of women by compelling them to have some definite share in the social service, for we all know that there is no greater cure for the blues and discontent than rational activity. By the socialization of domestic industry, if it could be brought about, the monotony of isolated home labor would be removed.

The difficulty with the woman who has too much work to do in the home and the woman who has not enough work to do is that they lack expressional freedom, partly from overfatigue and partly from lack of knowledge of the happiest means of self expression. It is a noteworthy fact that Massachusetts, where women are so largely employed in industry, stands forty-first in the matter of divorce, while Washington, where women are not much employed in industry outside the home, stands first, having produced 513 divorces to every 100,000 married couples. All this may go to show that women who are busy in social industry have little time to dwell upon grievances.

A good broadening course in our schools and colleges with a proper presentation of the duties of adult life would do much to lessen divorce, because after all the home is just what men and women make of it as a public utility in the development of efficient personality. Such a course would serve also to establish a tradition in favor of the homemaker and prevent in some degree the rush of women into outside industries which to many now appear attractive.

One of the difficulties with our educational system to-day from the kindergarten upward is that it seeks to make hard things easy, from the learning of the multiplication table to easy helps for Latin and kindred subjects. The only really satisfactory way of mastering the multiplication table is by definitely learning it. All through our educational system this spirit of helping children to avoid the hard things which require persistence and application is shown in our home life when neither men nor women are able to endure the hardships and unpleasant factors which do come up in every home at some time.

Instead of facing these difficult problems and bringing to bear upon them a rational mentality which will restore order from chaos and strengthen the bond of helpfulness between husband and wife, the husband and wife brought up by our educational system to look for

easy things, drift from not knowing how to assume responsibility in the home to avoiding it altogether by means of the divorce court.

There are no statistics to prove the statement, yet careful observation in a good many cases has shown that a cheerful common sense and ability to turn defeat into victory through perseverance would have kept many homes intact to-day.

And so, our educational system seems wrong when it permits our boys and girls to grow up looking only for easy places. Too many girls look forward to matrimony as a life of surcease from the disagreeable surroundings before marriage.

In consequence when the water pipes burst and the furnace grate falls out and the refrigerator springs a leak and the baby is teething and fretful and the meals must be prepared and the husband, owing to a belated breakfast, has not had time to be as affectionate as usual in his farewells as he ran for his car—when such a combination as this happens, as we housekeepers all know it can do—unless we are trained to listen for the eternal harmonies behind some of the discords of life, we are apt to grow discontented in home life because of our own inability to make a success of it and to bring to ourselves "cumulative happiness."

However, if we do have a sufficiently high ideal of our mission as homemakers and the spirit and necessary training to inform our task, we can set to work on our domestic problem with a cheerful courage, for we know that ice can be thawed and leaks mended, furnace grates repaired, cross, fretful babies can become the joy and light of a whole household, and belated husbands if only given a chance can more than atone for their seeming indifference.

The explanations just given are presented in order to make the point that an intelligent appreciation on the part of our girls of the responsibilities of home life and skilled knowledge on their part of how to perform their tasks will do much to prevent discontent in the home and desertion from it when unpleasant combinations really arise.

The natural conclusion from this fact is that our educational system should provide some way of showing every girl that she must expect serious conditions in dealing with the serious problems of life and that she must have some training for her fundamental task of developing vital personality with its resultant mental, moral and social responsibilities. Otherwise our whole industrial system must change so that domestic industries can become socialized and women do their share, specializing for home work according to inclination. But in either case for human evolution we must have trained guardians of the personality, whether they be natural mothers or selected ones.

This is not an easy program which is outlined for womankind, but it can be made a very efficient one in race development. The quickest

way to get desirable results is by wide-spread education, rather than by waiting for any possible change in our industrial system.

With an increased training in efficiency of women for home industry there can be expected less discontent with unsatisfactory conditions and consequently less divorce. The unity of the home will thus be strengthened and there will result improved conditions for the development of efficient personality.

Thus could be brought together through the necessity of woman's preparing food in the home the best demonstrated forces for the development of efficient social personality.

With a trained womanhood alert for defects and excellencies in home conditions, the home as a social organization in its aid to personality would in time be much improved, for evolution would demand new conditions and the women as guardians of the home through their training would be responsive to these demands.

That there is an awakened public conscience on the subject of the dissemination of knowledge concerning public health is shown by the facts that there is a movement on foot to take from the various government bureaus those departments which relate especially to public health and combine them in one health department, and a petition has been prepared for congress asking that it provide by its bulletins help for women in the homes similar to that which is furnished farmers by the Department of Agriculture.

All these are good signs of progress, but, after all, since now and for many years to come society is going to demand that woman be the guardian of the home, that she prepare the food, that she shall be her children's closest teacher and friend, the most efficient manner of developing personality in the home will be by suitable education of the growing girl and the young woman in preparation for her life's work.

Conclusions

The supreme test of our home organization according to the facts which have been stated is whether or not through its means there is an increase in vitality, mentality, morality and sociality and a decrease in the number of abnormal, unmoral, desocialized and degraded.

Some statistics tell us that when women remain in the home rather than go into outside industry, that there is greater steadiness and industry on the part of the husband, owing supposedly to more hygienic home conditions.

Statistics tell us also that longevity is increasing, that it has increased five years since 1855.

Then our homes, standing as they do as the connecting link between the knowledge of what is best for the race and the finished product in society, are doing a great work.

However, on the other hand, statistics as quoted above tell us that the death rate of infants is abnormally high, that preventable diseases are excessively prevalent, that divorces are too frequent, and that the "unpreparedness of women" is responsible for sickness, disability, degeneracy and resulting misery or maladjustment to society, and that if only the knowledge available for preventing disease could be disseminated and utilized, longevity would be much increased.

These facts show that while the mother in the home by the preparation of food and resulting responsibilities is doing much for race betterment, there is imperative need for greater ability in some way to enable woman to make use of the results of scientific research, in order that there may be in the human race "an increase of vitality, of sound and high mentality, and of sociality."

A practical service of the sociologist is to reveal points at which educational work will tell for race advancement; so an attempt has been made to show that a changed system of education for girls can do much toward a harmonious development of personality, and that this preparation of food for which society has specialized womankind may be fundamentally helpful in individual growth if the housemother can do what she does intelligently and does not do so much of it that she can have no sense of success in it.

The state assumes the right to say what training in its institutions people shall have who intend to practise medicine or dentistry, or law or to teach children in public schools. It ought to assert some control over the training of people who are to be in charge of the consumption of all wealth and of child culture in the home. The ordinary college education is not enough, for many unsuccessful homemakers have that.

The training for educated homemakers should include a thorough knowledge of the subject of personal hygiene with its three divisions: (1) nutrition, or a knowledge of the food requirements of mankind and the best way to provide for them; (2) environment, or a knowledge of air, soil, dwellings, clothing; (3) activity or a knowledge of the correct proportion between exercise and rest.

Each one of these divisions includes many departments of learning. To these subjects should be added a thorough knowledge of sex hygiene. With a knowledge of all these subjects should go an attitude of mind which is able to develop powers equal to one's tasks.

THE CONSTITUTIONAL CONSERVATISM OF WOMEN

By Dr. OTTO CHARLES GLASER
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IN the course of his essay on emancipation—black and white—written at the close of our civil war, Huxley says that with few exceptions the ideal of womanhood in his generation seemed to oscillate between Clärchen, on the one hand, and Beatrice, on the other. That women are intended neither as guides nor as playthings, but as comrades, fellows and equals, in so far as nature herself raises no bar to equality, at that time had not penetrated the minds of those entrusted with the education of girls. But even the densest media are ultimately permeable, and if we can now point with pride to certain accomplished results, it is because the underlying principles have not only been discovered and understood, but practically applied.

At heart these principles are biological, and the success which has attended their application depends on the fact that women share the senses, perceptions, feelings, emotions and reasoning powers of men, and that the average woman deviates less in these respects from the standard of men, than one brother differs from another. But problems are fatefully linked together, and the answer to one is invariably the herald of others. If the education of women has demonstrated both its feasibility and value, the inevitable next question clamors for solution no less insistently than its progenitor. Now that she is educated, what shall we do with her? Perhaps at this point biology can aid us anew and point the moral to a tale which itself may have proceeded no farther than the opening paragraph.

Whoever has sufficient temerity to read all that has been written on the subject of sex in twenty years, is likely, sooner or later, to revert with a sense of freedom to Geddes and Thompson's splendid work,[1] there to rejoice in a view by no means out of harmony with recent results, and so comprehensive that the truth, though still "in block," lies well within the field of vision.

Beginning with the simplest cases, and ending with the almost hopelessly complex sexual life of man himself, these writers reduce all to elementary terms in physiology, and find the fundamental difference between the sexes in the essentially disruptive diathesis of the male, and the essentially constructive diathesis of the female.

[1] Patrick Geddes and J. Arthur Thompson, "The Evolution of Sex," American edition published by Scribners.

These abstract characterizations, however, can convey little meaning without the evidence on which they rest. What does "constitutionally disruptive" imply, and what "constitutionally synthetic"? It is a far cry from humanity to the cochineal insect, yet this may serve as our point of departure. The well-known dye derived from this species is elaborated entirely by the females, who store it in huge quantities and as a result are condemned to a life of quietude on the sustaining cactus. The males, on the other hand, are small in size, quick in movement and short-lived.

This division of labor, though somewhat pronounced, is not a biological freak; it can be matched, more or less closely, many times, not only among insects, but among other animals, both lower and higher in the scale of being. Sexual differentiation among birds and mammals, however, manifests itself not by some one glaring difference of habit, but usually in smaller ways; in ourselves, in the sudden and strenuous outbursts of activity, characteristic of men, especially of young men, boys and barbarians, and in the patient, long-continued, and less violent expenditure of energy ordinarily seen in women.

Of course these distinctions are broad and have no bearing on individual cases. They serve rather as convenient, though well-founded rubrics under which to array the leading characteristics of the two temperaments whose existence affects our daily conduct in a hundred ways. Nor is this dealing with averages, whose constituent items merge unrecognizably in the multitude, disadvantageous, for in matters that seem to involve a whole kind, evidence from this or that individual affects the general result no more than my tall friend makes the average height of men other than it is.

While the males and females of fishes, reptiles and amphibians, follow the rule of the cochineal insect, exactly the reverse is true of birds and mammals, for among these the males are practically always the larger. In reality, however, maleness and femaleness are fundamentally unaltered throughout the living world, and the apparently contradictory evidence from the higher forms of life is traceable to their peculiar habits of reproduction.

Most important of all in this connection is brooding, for it throws light, from two angles at least, on the physical superiority of the male sex. Maternity, whether in birds or mammals, demands tremendous sacrifices—in fact is the very thing responsible for their higher development. Moreover, these sacrifices are not laid down in one lump sum, but bit by bit, and it may take years before all the premiums needed to insure a new life completely have been paid up.

Greater, albeit subtler, effects than come from these drains, are traceable to the inevitable stagnation of females incapacitated by incubation or pregnancy, for the quietude necessitated by these states is

offset by stress in the male. Food and protection must be furnished for two instead of one, and at times for more than two. It is because effectiveness during these critical periods is racially essential, that the males are larger, stronger and in general more pugnacious.

Our point of vantage includes also those flagrant expressions of masculinity, known as the secondary sex characters: among birds, the resplendent plumage of the cock, the comb and wattles; among mammals, manes, horns and scent glands; in man, the beard and deep voice. All these are the outward signs of maleness, for they come and go with the sexual life, and their development may be stunted or prevented by operation. Gelded stags never renew their antlers; sheep, oxen and antelopes grow inferior horns; whereas the preservation of valuable soprano voices in men is assured by the same means.

These effects are due to the absence of certain chemicals normally emanating from the male sex glands. Analogous results may follow in operated females, but usually most illuminating complications set in, for the female not only has distinctive characters of her own, but is largely dependent on the suppression of those belonging to the male. The functional derangements often associated with old age involve changes in the chemical output of the essential organs, and explain, not only the crowing hen in the barn-yard, but the greater resemblance of the sexes in senescence than in middle life.

All this is reducible to a chemical basis, certain substances being necessary for the development and persistence of the characters that stamp the male; others being essential not only for the positive traits of the female, but also to insure her freedom from male tincture. From the standpoint of the male, the female is an instance of arrested development, a conclusion bodily transferable to other attributes, for except in matters peculiarly her own the female is surpassed in amplitude by the male. Physiologically he cuts a wider swathe, and this inevitably involves greater variability. Accordingly we find that not only as an animal, but as a thinking being, man presents more departures from mediocrity than woman. On this point history testifies with her right hand up, for numerically and as individuals, men have always excelled, not only in knowledge and art, but also as sinners and fools.

We may blame the social heritage of women for the supremacy of men, but heritage and supremacy alike have their head-waters in the greater variability of the male sex, for variability means special fitness for advancement. Departure from traditions has ever been the first step of progress, and it is to our variants, our gifted men and geniuses, that we owe railroads, wireless telegraphy and airships; it is to them also that we are indebted for our greater stories, plays and poems, and even for our deepest thoughts. This type of man startles us by his originality, and brings into the world things before unknown.

The history of civilization, however, is only half written when all the departures from mediocrity have been listed and analyzed, for tradition clings inevitably to the coat-tails of departure, and holds it close to solid ground. If the greater variability of men is the gift that fits them to explore new fields, nothing is more certain than that the less erratic organization, both physical and mental, of women, fits them for administration, conservatism, tradition and culture.[2]

These special aptitudes are sexual differentiations no less truly than bristling beards and flowing tresses, and under modern conditions, infinitely more important. Nothing, however, could be more fatal to any cause, involving either men or women, than failure to recognize that the natural endowments of the sexes are complementary, racially essential and, fortunately, bred in the bone.

It is at bottom, failure to recognize this that has given rise to the current opinion that the emancipation of women through suffrage would destroy maternity. This, if it means anything at all, means that it will destroy sex. Those who have fears in this direction will do well to remember that the sex of woman is no less solidly grounded than the sex of man, and that both are infinitely older than our civilization whose earliest date is only this morning in the complete history of the race. We are the descendants of untold generations before Adam and Eve, and sex is more strongly inbred than the ten fingers.

Biology knows only racial justice, but racial justice in the long run will require suffrage for women, because they are constitutionally fitted for the exercise of the conservative influences of which, as a body politic, we stand so much in need. That the enlightened woman will wield her power without blocking progress, and, within human limits, for the prevention of errors, and the conservation of things worth while, follows both from her organization and her training. Society to-day is losing the services of a specialist in these matters, one too, not only endowed by nature but strengthened by education. When once this becomes clear, shall we continue to doubt her ability to face the waves of jingoism that periodically unsettle our markets and industries, distort the prices of living, and even carry us into trivial yet costly war?

[2] W. K. Brooks, "Woman from the Standpoint of a Naturalist," *The Forum*, Vol. 22.

FLOATING ISLANDS

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IF one should see in a story the statement that a floating island 100 feet square, upon which were growing trees thirty feet in height, was used by the hero as a place of refuge, and that the island traveled 1,000 miles out to sea, he would probably accuse the author of an abuse of the imagination. But such an island—without the hero—was seen off the coast of North America and is known to have traveled at least 1,000 miles. Floating islands also occasionally occur in the lakes of some of our northern states. It is the purpose of this article to point out the location of some of these islands and to explain their origin.

In order to understand the formation of a floating island let us imagine a pond on the edges of which rushes and grasses are growing. These gradually push their way out into the deeper water, leaving a mass of decaying vegetable matter upon which, in time, mosses such as sphagnum may secure a foothold, and start a shelf which will extend out into the water. As soon as the sphagnum has become well established, water-loving plants and shrubs such as alders, sheep laurel and sweet gale will grow with the moss. Cranberries and pitcher plants may also aid in the formation of the mat, forming the familiar cranberry bog. This shelf will be attached to the shore for several feet, the distance depending on the depth of the water, but the peat will seldom attain a thickness of more than three feet. After the mat has become firm, black spruces and larches may grow upon it, often anchoring it and always making it more compact by means of their roots. Such a mat is illustrated by the drawing on page 304.

After the shelf has extended itself some distance into the pond, if the water level is raised unusually high by excessive rainfall or the construction of a dam across the outlet, the mat may break off and form a floating island. This island will either become attached near its former position by roots extending underneath it, or it will float around the lake.

In case the pond is small and nearly circular the mat may surround it. If the water in the pond is raised, at the time when all but the center of the pond is overgrown, an atoll or ring-shaped island may be formed. For the persistence of this atoll the water must remain at its high level and the atoll must become anchored.

Finally, let us suppose that the vegetation completely covered the lake before the water rose. There is sufficient elasticity in such a mat to permit it to rise slightly with a rise in the water level. The mat, however, is not sufficiently elastic to permit its center to rise more than

CROSS-SECTION OF A LAKE, showing a mat of vegetation growing out from both sides. A rise in water level might break off this shelf, and thus form a floating island.

a few feet, if the sides remain attached, and consequently it may disappear with unusually high water. In order for it to reappear either the water must go down or some agency must push the center up higher. This agency is marsh gas. This gas with its light specific gravity could exert such a force on the center of the mat that it would be buoyed up. In order for the gas to act in such a manner it must be present in large quantities and must not escape until that mat has reached the surface. When the gas escapes the mat will again disappear. This alternate appearance and disappearance of the mat makes it a periodic island. A true periodic island would not be attached to the sides. Such islands are rare, and conclusive evidence is lacking to show that they are not attached.

The various ways in which floating islands, floating atolls and periodic islands may originate are as follows:

I. FLOATING ISLANDS are divided into—(*A*) natural islands and (*B*) artificial islands.

(*A*) Natural islands may be formed by:

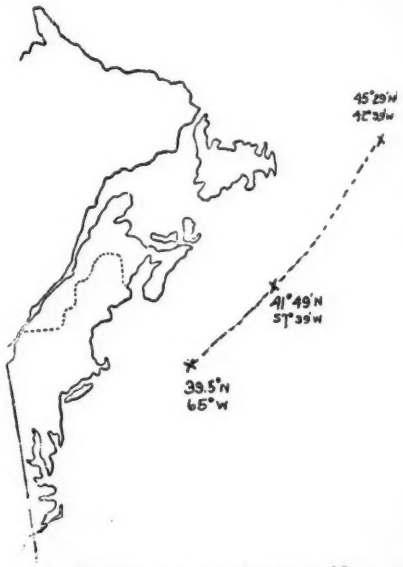
1. The coming together of floating vegetable masses. This hypothesis demands sufficient floating material upon which there is plant life of a suitable kind, or upon which plant life may start. There must also be some favorable agency to collect this material. In a large lake where high waves could break off pieces of sphagnum from the shore, the waves might collect the pieces so as to form a floating island. In small lakes, cat-tails or other rushes form a favorable place for such material to lodge.

2. The action of waves beating against a mat of vegetation may by their force break off large islands. This could happen only in the case of a large body of water and would probably account for the origin of the floating island mentioned in the introduction which was seen in the Atlantic Ocean in 1892. When first noticed in July in latitude

CROSS-SECTION OF SADAWGA LAKE, WHITINGHAM, VT., showing two floating islands. The large island grew out from the shore and was broken off by high water. It is now attached at the east side.

39.5° N., longitude 65° W. the island was about 9,000 square feet in extent, with trees thirty feet in height upon it, which made it visible for seven miles. It had apparently become detached from the coast of this country and been carried out to sea by the Gulf Stream. It was again seen in September in latitude 45° 29′ N., longitude 42° 39′ W., after it had passed through a severe storm. By this time it must have traveled over 1,000 nautical miles, and it may have eventually arrived at the coast of Europe.

3. The raising of the water level separates mats from the shore, as previously explained. An interesting case under this heading is that in which there are two kinds of peat in an overflowed bog. If the peat is arranged in layers, the bottom layer being heavy, since it is formed by the decompositon of woody material, may separate from the top layer which is light on account of its sphagnum content. In this circumstance the bottom layer remains in its former position, the upper layer breaking away to form a floating island.



A SECTION OF AN OUTLINE MAP OF NORTH AMERICA, showing the course of a floating island which was seen floating in the Atlantic Ocean in 1892.

4. The action of ice in the northern climates sometimes separates masses of vegetation from the shore. This expansion and contraction of ice is often an important factor in forming shore topography and an overgrowing mat could offer but feeble resistance to this force.

(*B*) Artificial islands may be formed by the damming of ponds or lakes, which is a very common mode of origin of floating islands in this country. An example of this type of island is that in Sadawga Lake shown in cross-section in the second sketch.

II. ATOLLS

Two atolls in central Minnesota. which are characteristic of all such atolls, have been described by Conway MacMillan in the *Minnesota Botanical Studies,*[1] and the following description of them is taken from that article.

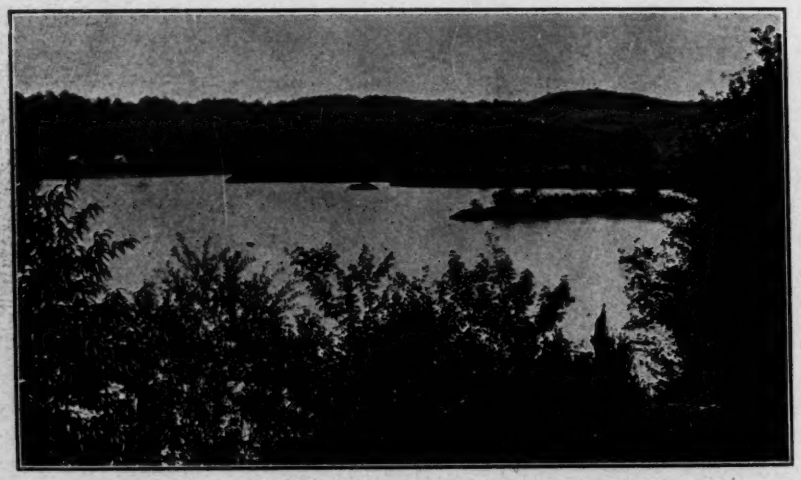
> The [larger] pond is about 150 yards across and almost circular in shape. It is surrounded, except for a short distance on the west, by rather precipitous morainic hills 50–75 feet in height. . . . [The atoll] is about 75 feet in diameter and of uniform width of about ten feet. On the west its continuity is broken by a channel, twelve feet across, which furnishes communication between the

[1] 1894, Bul. 9, Vol. 1.

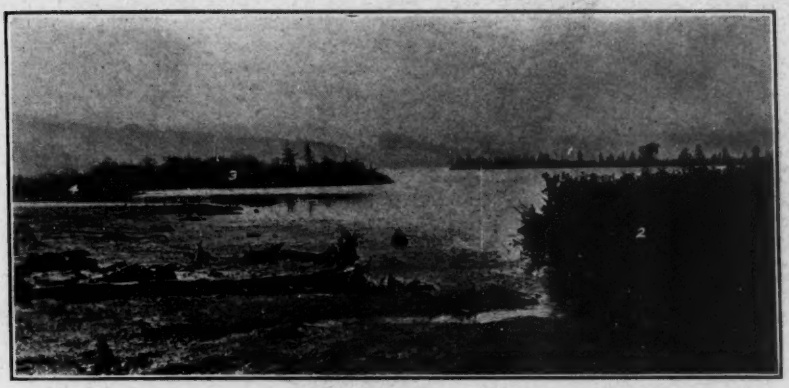
waters of the intra-insular lagoon and those of the pond outside of the atoll. The depth of the water is nowhere great. The greatest depth is about twelve feet and this maximum of depth is in the middle, within the lagoon. . . . The general texture of the atoll was loose, so that one standing anywhere upon it soon sank into the soft and spongy mass up to the knees. . . .

[The smaller] pond is barely fifty yards across, with high banks, and the atoll ring is within a foot or two of twenty yards in diameter. Its breadth, however, is greater than that of [the other] atoll, being twelve feet on the average from the outer to the inner aspect. The lagoon, then, is slightly less than fifty feet across. . . . The water of the pond was shallow, averaging four feet, just outside the atoll ring. . . . In general the texture of the atoll was much firmer than that of [the other] atoll. One could stand anywhere upon it without sinking in above the insteps.

The explanation of the presence of sphagnum atolls may be derived from the assumed changes in level of the pond water, and indeed their presence may, conversely, be held to indicate, or to demonstrate, fluctuations in the pond level. If it be possible to conceive that in these two atoll-producing ponds there has been, during the course of years, a gradual diminution in size followed by a rather rapid increase in diameter and depth, I believe the formation of the atolls would become a phenomenon readily comprehensible. . . . Concomitantly with the diminution in size, doubtless extending over a term of years, vegetation of the shoreward area would have established itself in characteristic zones. The littoral flora and the submerged plants just outside the shores would have formed a loose turf lining the edges of the pond. This turf would have gradually become more solid as it extended landward and would therefore at a little distance from the water's edge have become modified in character, giving a foothold for plants of larger growth. . . . When, subsequently to this epoch of gradual diminution, the ponds began to increase again, the effect of the rise in level of the water was to detach from the shore a ring of the loose littoral turf, and this mass of vegetation with its attendant soil, buoyed up at first as a circular floating bog, appears to-day as the characteristic sphagnum atoll. . . . The increase in size [of the pond] left the annular ring far out in the waters of the pond . . . and as the mass of vegetation and soil became thoroughly saturated with the water below, its character may gradually have changed until



A View of Sadawga Lake, Whitingham, Vt. Two floating islands are shown in the central part of the picture, and behind them is the main floating island from which they have become detached.



ANOTHER VIEW OF SADAWGA LAKE, showing the main floating island (1) and three smaller floating islands which have been broken off from it and have drifted ashore.

the sphagnum plants retained vitality. Generations of these succeeding each other contributed to the weight of the ring and finally pressed it down upon the bottom of the pond, forming the anchored atoll of the present.

[The essential requirements in the formation of atolls are] a small parent pond, height and regularity of banks, regular and gentle slope of the bottom, suitable original littoral vegetation, small lateral pressure and tension of winter ice, and comparatively prompt anchoring of the bottom.

III. PERIODIC ISLANDS

As previously explained, periodic islands may rise without the formation of gas, but as gas usually escapes from them after they have risen, irrespective of the force causing them to rise, it is a factor which demands attention. Under the average floating island there is little gas, owing to the loose texture of the peat. Consequently, in order to have gas support islands it is necessary that an upper layer of the bog be made of dense material, thus allowing the gas to escape but slowly. The most favorable place for it to collect is between the layers of peat. This is illustrated by experiments[2] in digging peat from a bog filled with water. Holes were dug in the evening of one day and the next morning they were found to be filled with peat masses in the form of domes, cleft in the middle. These domes were formed of one of the lower layers of the peat. The gas under this layer combined with lateral pressure forced it up.

Periodic islands usually rise in spring and sink in fall, owing to the activity of gas-producing organisms in warm water. Some periodic islands have been reported which rose for only a few days. Because of the short time which most of these islands have been known, it has been impossible to study them. Attention is now being given to one in this country and it is to be hoped that through its study valuable information will be obtained regarding this type of island.

[2] Früh und Schröeter, "Die Moore der Schweiz," *Beitr. geol. Schweiz Geotech.*, ser. 3, Bern, 1904.

PROFESSOR WHITMAN AND A GROUP OF RESEARCH WORKERS IN THE MARINE BIOLOGICAL LABORATORY IN 1893

THE PROGRESS OF SCIENCE

PROFESSOR WHITMAN AND THE MARINE BIOLOGICAL LABORATORY

At the annual meeting of the corporation of the Marine Biological Laboratory held at Woods Hole in August, resolutions were adopted recording the obligation of the laboratory to the great man who more than any other was responsible for making it what it is, and after the adjournment of the meeting the trustees and members of the corporation visited the quiet graveyard by the sea where lies the body of Charles Otis Whitman.

> Keen
> In intellect, with force and skill
> To strive, to fashion, to fulfil,

Whitman was born to be a leader. In his zoological researches he exhibited a patience, a balance, a singleness of purpose, a certain classical quality, which placed him among the few worthy to be named with Charles Darwin. His two principal researches, the one on the embryology and phylogeny of the leaches, the other on the phylogeny, heredity and behavior of pigeons, gave rise to a number of papers, which in content and form may be ranked among the masterpieces produced in this country. But in both cases a great part of his work remains unpublished. He was impatient of quick results and sought for fundamental solutions of great problems which perhaps his material was incapable of yielding. There remains, however, a great mass of manuscripts, observations and drawings, together with the unique collection of living pigeons, which will yield a valuable series of publications.

In spite of the fact, or perhaps on account of the fact, that Whitman devoted himself to his research work with complete devotion, he exercised an exceptional influence on zoological education and organization. He was professor in the University of Tokyo at the time when that university was being adapted to modern conditions. When Clark University was organized, he was given charge of the work in zoology, and again on the establishment of the University of Chicago. The department of zoology there, of which he was head until his death, took high rank among the scientific departments, which in a few years have given Chicago distinction in science, equaled only by Harvard and Columbia. Whitman's varied activities are noted in a resolution passed at the Christmas meeting of the Eastern Branch of the American Society of Zoologists, which reads:

> The Eastern Branch of the American Society of Zoologists records with profound regret the death of Professor Charles Otis Whitman on December 6, 1910. Professor Whitman was one of the founders of this society; he was chairman of the committee that issued the first call for organization of the American Morphological Society, the forerunner of the American Society of Zoologists, and he was president of the society for the first four years, 1891–94. He was organizer of the *Journal of Morphology* and its editor for many years, and in this capacity also exerted a strong influence on the development of zoological research in America. As director of the Marine Biological Laboratory for twenty-one years, he exerted an even more powerful and entirely unique influence in the development of biological science. As an investigator he was painstaking, enthusiastic and thorough, as a thinker on biological problems profound and far-sighted. Devoted to principle, his uncompromising personality sometimes made enemies, but the charm of his character made him devoted friends. His influence will long remain as one of the most important forces in the history of zoology in America.

The Woods Hole Laboratory was the

institution for which Whitman cared the most and it remains his greatest monument. It is fortunate in its physical environment; still more so in the spirit of the place. More biological research is accomplished there during its season than in any other institution in the world. Both in its formal organization and in its real life it is more democratic than any other American institution devoted to education and research. The result has been, on the one hand, a share of dissensions and poverty; on the other hand, a rare exhibition of cooperation and loyalty. It is false to assume that a democracy should not have leaders. In an autocracy masters hold the reins of authority; in a democracy a leader is followed because he is recognized as such. For many years Whitman was the creative spirit which gave life to the Marine Biological Laboratory. In a note, printed here by permission of Mrs. Whitman, he wrote:

I have often been pleasantly commended for the development of ideal conditions at Woods Hole for cooperative teaching and research, and I think that most of the best friends and patrons of the Marine Biological Laboratory still credit me with qualities that tend to peace and good fellowship in scientific work.

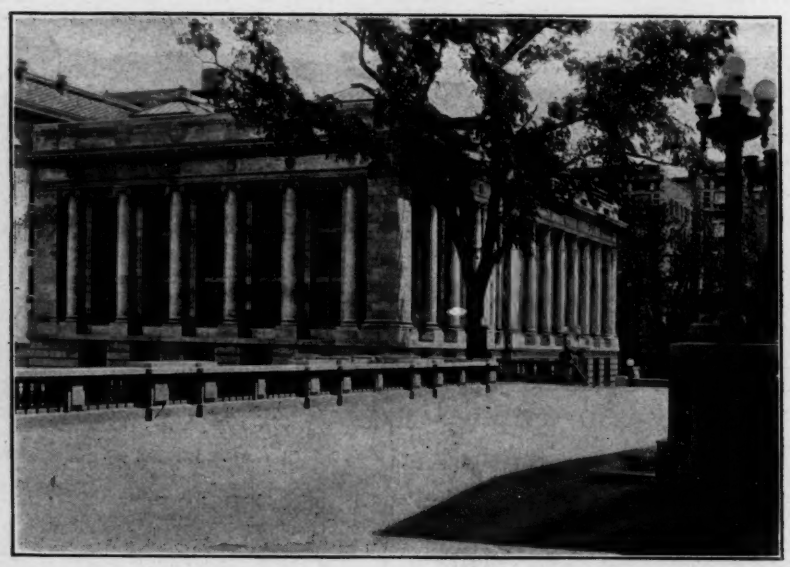
I have, I am happy to say, endeavored to live by the same principles in Chicago. That is, I have done what I could to encourage the spirit of research and good fellowship in both teaching and research.

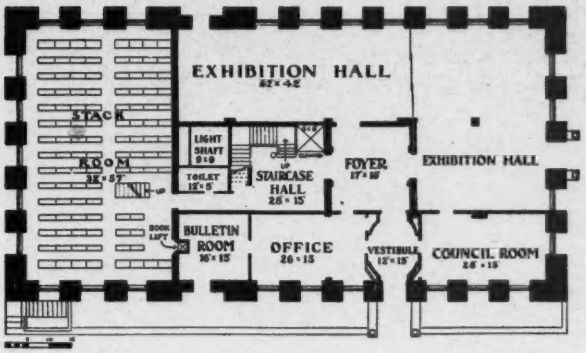
I have opposed all attempts to create interdepartmental kingdoms; I have left each member free to develop his work according to his own taste; have never monopolized any line of work, but have always welcomed synthetic cooperation. The seminar and the researches abundantly verify this.

One thing, from first to last, I have most cordially despised—that is the tendency to that disease, which we may distinguish as administro-citis. That disease is the peril of science, and the source of unwholesome strife. Our organization is of course largely at fault, for it certainly misleads many to imagine that the one sure road to precedence is to scheme for it through administrative dexterity.

THE AMERICAN GEOGRAPHICAL SOCIETY

THE American Geographical Socieity, which was founded in New York City in 1852 and has now about 1,300 members, moved ten years ago to a building opposite the American Museum of Natural History. But it soon outgrew





its quarters and has now again moved to a new site on Broadway and 156th Street, adjacent to the fine buildings of the Hispanic Society of America and the American Numismatic and Archeological Society. It has now a beautiful site by the Hudson River in one of the scientific centers of the city. It is unfortunate that all the institutions devoted to higher education, science and letters could not have been placed in one center, but they are at all events in large measure connected by the subway on the west side of the city.

By the courtesy of Mr. F. S. Dellenbaugh, the secretary of the society, we are able to print here some illustrations showing the exterior and interior of the admirable new building, which has been occupied by the society since May. It is built of Indiana limestone in the style of the Italian Renaissance, conforming to the other buildings on the ground. There are four stories and a basement; the stack rooms form the western part of the building, being placed on six floors. The whole building is admirably designed for the purposes of a geographical society, being completely fire-proof, with ample light on all sides. It will provide a permanent home for the library and collections of the society and for its educational and scientific work.

SCIENTIFIC ITEMS

WE regret to record the deaths of Professor Benjamin Franklin Thomas, professor of physics in the Ohio State

University, and of Dr. Johann Paul Schweitzer, emeritus professor of chemistry in the University of Missouri.

THE Paris Academy of Sciences has awarded its Lalande Prize to Dr. Lewis Boss, director of the Dudley Observatory, Albany, N. Y. Its general prizes, each of the value of $2,000, have been awarded to M. Jules Tannery, of Paris, for his mathematical publications, and to M. Déperet, of Lyons, for his geological publications.

PROFESSOR L. H. BAILEY has tendered to the trustees of Cornell University his resignation as director of the New York State College of Agriculture.—Dr. E. C. Franklin, professor of organic chemistry at Stanford University, has become professor of chemistry in the hygienic laboratory of the Public Health and Marine-Hospital Service.—Professor Clyde Furst, secretary of Teachers College, Columbia University, since 1902, has become secretary of the Carnegie Foundation for the Advancement of Teaching, succeeding Mr. John G. Bowman, who has become president of the University of Iowa.—The director of the Museo Nacional, Mexico, Sr. Garcia has resigned and Sr. Robelo has been appointed in his place. Sr. Batres, inspector of antiquities, is succeeded by Sr. Rodriguez.